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SPECIFICATIONS FOR THE DEVELOPMENT OF INSTRUCTION MANUALS FOR AUTOMATIC AIR MONITORING INSTRUMENTS

APPLIED SCIENCE ASSOCIATES, INCORPORATED

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16. ABSTRACT

The contract report "Specifications for the Development of Instruction Manuals for Automatic Air Monitoring Instruments" was produced to provide a comprehensive set of specifications to guide manufacturers in the development of instruction manuals for continuous air monitors. The report provides in the first section, background information as to the need for such specifications, who should use it and how it should be used. The second section contains the specification itself. Chapter and appendix topics include maintenance task analysis, job guides development, troubleshooting aids development, quality and accuracy assurance procedures, definitions, and guidelines for review and evaluation of instruction manuals. Sf

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by

Richard L. Dueker

Applied Science Associates
Box 158
Valencia, Pennsylvania 16059

Contract No. 68-02-1078

EPA Project Officer:

Stanley F. Sleva

Prepared for

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PREFACE

This document introduces and presents a set of specifications to guide manufacturers in the development of instruction manuals for automatic or continuous air monitors (CAMs). This section will provide background as to the need for such a specification, who should use it, and how it should be used. The second section consists of the specification itself.

Background

It has long been obvious to those who frequently depend on manufacturer supplied documentation for use and maintenance of complex equipment that, while some of the documentation is clear, complete, and accurate, much of it is woefully inadequate. The instruction manuals provided with continuous air monitoring instruments are no exception. It is not uncommon to have such a manual which, though attractive in appearance, has technical inaccuracies, does not provide enough information, and/or is confusing to use. Often, the highly experienced technician can keep a CAM operating and performing accurately despite shortcomings in its supporting documentation. A problem occurs, however, when such technicians are unavailable. A malfunctioning instrument can be out-of-service for extended periods while awaiting a qualified person to troubleshoot and repair it in the field, or while the instrument is returned to the manufacturer. At least as bad, the instrument can be operating marginally, reporting bad data, due to improper installation, operation, calibration, servicing, or malfunction. Such a condition might exist undetected for some time.

To rectify this situation, CAM support documentation with the following characteristics is required:

1. Clarity. The information presented in the manual must be understandable and unambiguous. The meanings of all terms should be clear, and their use should be consistent throughout

the manual. Sentence structure, length, and complexity must be suitable to the technician who must use the manual.

2. Completeness. The manual must cover all the task areas the technician is likely to encounter—installation, operation, calibration, preventive maintenance, troubleshooting, and corrective maintenance. Individual tasks within a given task area should be described where there is any doubt that the typical user technician could perform correctly without aid. All the information needed to perform each such task must be provided.

3. Accuracy. All information provided in the manual (e.g., sequence and content of task steps, test outcomes, tools and materials required, parts numbers, illustrations) must be correct for the identical instrument(s) with which the manual is supplied. A common practice among instrument manufacturers is to modify an instrument without updating the supporting documentation. This practice puts the technician in the position of, for example, trying to locate a part on the instrument using an illustration which does not correspond to the instrument. At best, this causes confusion and delay; at worst, it renders the manual useless for the given application.

4. Simplicity. The manual must be designed for use by persons with a limited technical knowledge and skill. Formal technical training/experience or a background in the maintenance of CAM instruments should not be required. This permits a much greater share of instrument maintenance to be accomplished by semi-technical personnel (such as the CAM operators) and reduces dependence on senior technicians and factory service personnel.

5. Emphasis on Troubleshooting. The key to keeping the CAM operating and performing accurately is systematic and thorough troubleshooting. The large majority of CAM instruction manuals currently available fail to provide a step-by-step procedure for assuring that the CAM is working properly, and, if it is not, for leading the technician to the specific malfunctioning part(s).

In recent years, much work has been done toward producing better complex equipment support documentation. A major example of the outcome of such work is the Job Performance Aid (JPA) approach. The JPA approach is a detailed but practical technique for developing support documentation which meets the above criteria. The approach leads the instruction manual developer through determination of what must be included in the manual, gathering of preliminary data, development of the manual, and validation. Two JPA products result from the use of this approach.

1. Job Guides, which are standard format presentations of supporting information and step-by-step procedures for performance of individual tasks (e.g., install, replace a given part, calibrate).
2. Troubleshooting Aids, including Checkout Procedures, to ascertain whether the instrument is operating properly, and Action Trees, which trace out the symptoms located by the checkout to isolate specific malfunctioning parts.

A primary goal of the JPA approach is to lead the manufacturer to discover and include in his documentation all the information the instrument user must have in order to install, operate, calibrate, service, repair, and troubleshoot the instrument. This is a quite different emphasis from what often occurs. In many cases, the manufacturer spends a minimum amount of time and money on the manual initially, and updates the manual as errors and problems are uncovered by users in the field. Application of the JPA approach by the instrument manufacturer assures the instrument purchaser that, even with newly-developed instruments, the supporting documentation will be usable, complete, and accurate.

Application of the JPA approach has the additional advantage of improving the quality of, particularly, the newly developed or modified instruments. The approach requires that the instruction manual be 100% validated, including all normal and emergency modes of operation. The validation serves the purpose, not only of validating the manual, but of uncovering inability of the instrument to meet its performance specifications. This holds true, as well, where an existing design undergoes modification, since the JPA approach requires development of updated (and validated) documentation reflecting each instrument modification. In addition, the purchaser of an instrument which has undergone several modifications since its original design will be assured that the instruction manual he receives with his instrument relates to that identical instrument.

In order to help meet the goals of EPA's quality control program for environmental monitoring, a major effort must be made to improve the quality of CAM support documentation. The Job Performance Aids approach has been shown, in applications involving complex military and civilian equipment and equipment systems, to result in a type of documentation which would be of great benefit to CAM purchasers. The specification included in this report was designed, therefore, to employ the JPA approach to guide and constrain manufacturers in the development of support documentation for automatic or continuous air monitoring instruments. There are several key features in the specification:

1. It provides not only the required characteristics for CAM instruction manuals, but the procedure by which the manuals are to be developed.
2. The audience to which the manuals are to be written is specifically defined, i.e., the general education level, experience, and skills/knowledge are specified for the lowest level of personnel who must be able to successfully use the manual.
3. The specification provides the CAM purchaser with the option of performing quality assurance spot checks on the interim products generated during the manual development process.

4. The purchaser also has the option of verifying the manual immediately upon delivery and specifying corrections to be made in the manual, as discovered during verification.

Who Should Employ the Specification

As noted above, the specification was generated to encourage the development of high-quality CAM support documentation. In order for it to achieve its purpose, it must be included, along with the more usual specification of required instrument performance and use characteristics, in the bid information provided to prospective CAM suppliers. The specification may be employed both by those elements within EPA who have reason to purchase CAM instruments and by state and local air pollution control agencies. While the availability of JPA-type CAM support documentation will be of value to agencies of all sizes, JPA documentation will be of special benefit to the medium to small agencies. It is agencies of this size which are most vulnerable to CAM system performance degradation due to instrument malfunction, since they less often have budgets which permit the purchase of back-up instruments or the full-time employment of highly skilled technicians.

Using the Specification

While simply including the specification in the bid information to prospective CAM suppliers will assure the purchase of much more complete and usable support documentation, the purchaser can, if he desires, use the specification to assure that the documentation meets his unique needs. The specification provides that the purchaser can review the interim products which will be used to develop the instruction manual, during the manual development process. If the manufacturer already has a manual for the instrument in question which was developed according to the specification, the purchaser can elect to review the document and the interim products from which it was developed, as part of the bid evaluation. This means that the purchaser can, for example, review the manufacturer's rationale for including or excluding a given maintenance task and decide, based on the capabilities of his own technical personnel, whether that decision was appropriate for him. Guidelines for performing such review are included as Appendix A.

Once the instrument and its supporting documentation are delivered, the specification provides that the purchaser can verify the manual to assure that it is correct and in compliance with the specification. The purchaser can determine, for example, whether the troubleshooting can uniquely identify a given faulty part, or that the Job Guides do provide all the information necessary to correctly perform their respective tasks. Guidelines for performing verification are given in Appendix B.

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SPECIFICATION OF INSTRUCTION MANUALS
FOR
AUTOMATIC AIR MONITORING INSTRUMENTS

1. SCOPE

1.1 Purpose. This specification establishes the requirements for content and format of the instructional and technical documentation to be provided by the vendor to support the use of automatic or continuous air monitoring instruments. It includes requirements for intermediate data products necessary to the proper development and adequate quality assurance of the documentation.

1.2 Benefits. The intention of this specification is to provide benefits as described below, to both procuring agencies and vendors.

1.2.1 Procuring Agency Benefits. Application of this specification is intended to provide procuring agencies with documentation which:

a. Is clearly written and accurate.

b. Can be successfully employed by relatively unskilled technical personnel.

c. Is complete in the sense of covering all necessary instrument-related tasks and providing all information required to correctly perform those tasks.

d. Provides troubleshooting which can lead systematically to the detection of a malfunction in any field-replaceable part in the instrument.

1.2.2 Vendor Benefits. Benefits can be expected to accrue to instrument vendors as a result of validation (see 6.3). The process of validation will demonstrate the ability of the instrument to perform according to the required instrument performance specifications. Failure of the instrument to perform adequately can then be dealt with during development. The need for costly field modifications and updating of existing documentation can be much reduced.

1.3 Philosophy. This specification employs the Job Performance Aid (JPA) concept and approach. JPA-type instruction documentation (hereafter referred to as "Instruction Manual" or "manual") is intended to provide detailed, accurate, and complete information in a standard and systematic manner. The emphasis is on providing a technician, whose abilities are known (see subsection 1.5), with just that information he requires to perform a specified task (e.g., install) on the instrument. The information is provided in an easy-to-use fully proceduralized format which guides the technician step-by-step through the performance of the task. The vendor will be expected to adhere to this philosophy in the development of the Instruction Manual for the subject procurement.

1.4 Content/Coverage. The Instruction Manual provided in accordance with the subject procurement shall cover, in the manner outlined elsewhere in this specification, tasks related to the installation, operation, calibration, preventive or periodic maintenance, troubleshooting, and corrective maintenance of the subject instrument. The coverage in the Instruction Manual shall be of the identical model and configuration as the subject instrument. That is, all text information and all illustrations shall relate to exactly the same parts and physical layout of parts within the instrument as pertain to the delivered instrument.

1.5 Intended Audience for the Instruction Manual. The instruction manual shall be written for user technicians within the procuring agency who have the following minimum qualifications.

1.5.1 Aptitude/Intelligence. The user technician may be assumed to possess levels of mechanical and electronic aptitude and general intelligence normal to the population at large.

1.5.2 Formal Education/Reading Level. The user technician may be assumed to be a high school graduate and have a ninth-grade reading level.

1.5.3 Formal Technical Training/Experience. The technician will be assumed to have had no formal training or experience in the theory or maintenance of chemical/electrical/mechanical systems, except as described in 1.5.5.

1.5.4 Previous Training/Experience with the Subject Instrument. The technician may be assumed to have had no previous training on or experience with any of the tasks in the Instruction Manual.

1.5.5 Uɴᴅᴇʀʟɪɴᴇ

1.5.5 User Technician Assumed Input Repertoire. The user of the Instruction Manual may be assumed to possess the following skill and knowledge elements:

a. Knowledge of the tools and materials required for maintaining the instrument sufficient to permit identifying, locating, and correctly using them.

b. Ability to detect worn, corroded, dirty, broken, or otherwise defective component parts by visual, tactile, or auditory examination and comparison to properly functioning parts.

c. Ability to coordinate adjustment-screw or hand-knob movements.

d. Ability to detect leaks in tubing and piping connections using simple leak-detection aids, as appropriate.

e. Ability to detect pinched, ruptured, or otherwise defective tubing, and incorrect tubing connections.

f. Ability to connect/disconnect standard tubing and piping connectors, achieving leakproof connections and without injury to threads. This includes the use of teflon tape, as appropriate.

g. Ability to connect/disconnect standard electrical connectors. This includes identifying wires to facilitate correct connection, and achieving tight connections without damage to the leads or terminals.

h. Ability to correctly interpret function diagrams, wiring and tubing diagrams, and troubleshooting charts.

i. Ability to use a VOM, VTVM, or multimeter to achieve accurate circuit measurements without damage to the instrument.

j. Ability to solder and unsolder electrical terminals, making a good electrical and mechanical connection without shorting or grounding the connection, or damaging circuit components.

k. Ability to accurately read and interpret (using calibration curves, as required) the following:

(1) Regulator pressure gauges

(2) Flowmeters

(3) Micrometer dials

(4) Instrument meters

(5) Strip charts

(6) Max/min reading thermometer

(7) Line voltage meter

(8) Liquid levels (e.g., using a graduated cylinder)

l. Ability to plot a line of best fit using the least squares technique, given a step-by-step procedure.

m. Ability to make computations involving several variables, given a step-by-step procedure showing individual addition, subtraction, multiplication, and division operations.

n. The ability to handle caustic or otherwise dangerous reagents without injuring personnel, damaging equipment, or contaminating the reagent.

o. Ability to accurately obtain definite volumes of solutions using apparatus such as a pipette, syringe, volumetric flask, or burette.

p. Ability to use an analytical balance to obtain an accurate weight of a dry reagent. This includes the ability to:

(1) Zero the balance.

(2) Adjust sensitivity range without extreme changes which might damage the balance.

(3) Read and interpret the indicated mass.

q. Ability to assemble sample apparatus with each component in proper sequence, using butt-to-butt connections, tygon tubing, and silicone or fluorocarbon grease as appropriate to create a leakproof assembly.

1.5.6 Additions to the Input Repertoire. Additions may be made in the user technician assumed input repertoire, as set forth in 1.5.5, only with the approval of the procuring agency. Such additions when approved shall be documented and become part of the user technician assumed input repertoire to be used in the development and quality assurance of the various JPA products.

1.6 **Instruction Manual Development**. It is intended that the development of the Instruction Manual for the subject instrument should follow a prescribed sequence of steps, as described elsewhere in this specification. A flowchart, outlining the sequence of these developmental activities, is provided in Figure 1. The number(s) in parentheses following each activity title refers to the subsection of this specification pertaining to the activity.

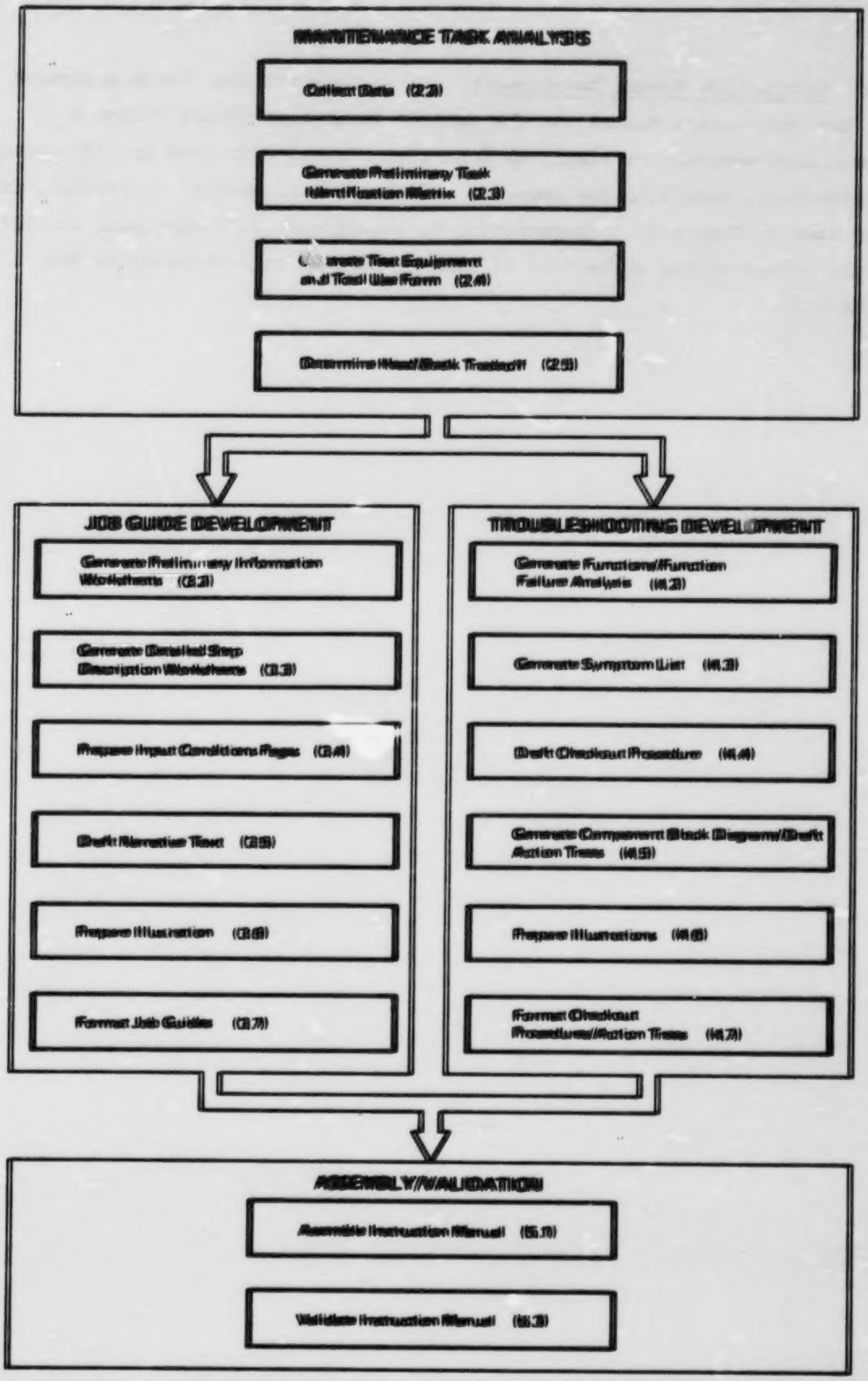

MAINTENANCE TASK ANALYSIS
Collect Data (2.2)
Generate Preliminary Task Identification Matrix (2.3)
Generate Test Equipment and Tool Use Form (2.4)
Determine Head/Back Tradeoff (2.5)
JOB GUIDE DEVELOPMENT
Generate Preliminary Information Worksheets (3.2)
Generate Detailed Step Description Worksheets (3.3)
Prepare Input Conditions Pages (3.4)
Draft Narrative Text (3.5)
Prepare Illustration (3.6)
Format Job Guides (3.7)
TROUBLESHOOTING DEVELOPMENT
Generate Functions/Function Failure Analysis (4.2)
Generate Symptom List (4.3)
Draft Checkout Procedure (4.4)
Generate Component Block Diagrams/Draft Action Trees (4.5)
Prepare Illustrations (4.6)
Format Checkout Procedures/Action Trees (4.7)
ASSEMBLY/VALIDATION
Assemble Instruction Manual (5.1)
Validate Instruction Manual (5.2)

Figure 1. Flowchart of Instruction Manual Development Sequence

2. MAINTENANCE TASK ANALYSIS

2.1 Purpose. The purposes of the maintenance task analysis are to:

a. Generate and/or collect required technical data to support the development of Job Guides and Troubleshooting Aids.

b. Identify all tasks to be described within the Instruction Manual and all maintenance significant parts (MSP) to be isolated through troubleshooting.

The following intermediate products shall be prepared in accordance with the requirements specified herein:

a. Preliminary Task Identification Matrix
b. Test Equipment and Tool Use Form
c. TIM Annotated for Head/Book Tradeoff

2.2 Data Collection. Data for use in preparing the various interim products described in this Section and in Sections 3 and 4 shall be gathered as set forth below.

2.2.1 Data Sources. The following types of documentation shall be collected. The most recent issues at the time the task analysis is performed shall be used. The data sources shall include but are not limited to:

a. Functional flow block diagrams
b. Schematic block diagrams
c. Electrical schematics
d. Engineering drawings
e. Instrument specifications
f. Parts vendor-supplied specifications, drawings, pictures, maintenance requirements, etc.
g. Special tools and test equipment manuals
h. Illustrated parts breakdown
i. Existing instrument installation, calibration, operation, maintenance, and troubleshooting manuals
j. Engineering reports
k. Field data, including observational data on maintenance operations as performed on prototype and/or procurement-identical instruments.

2.2.2 Duplication of Effort. The preparation of the maintenance task analysis shall not result in duplication of effort. Valid data which have already been prepared as part of instrument development shall be used where available and applicable. The data shall be incorporated in the intermediate products by reference.

2.2.3 Use of Computer. The use of a computer for data storage and retrieval is acceptable. Data formats specified in this Section and in Sections 3 and 4 may be modified for computer use so long as the information requirements and deliverable data requirements of this specification are met.

2.3 Preliminary Task Identification Matrix. A Preliminary Task Identification Matrix (PTIM) as shown in Figure 2 shall be prepared in accordance with the requirements set forth in the following paragraphs.

2.3.1 Instrument Hardware Item and Code (i.e., row headings). The names for subsystem, equipment, group, etc., down to the MSP level shall be entered in the rows of the PTIM, as illustrated in Figure 2. The method of subordination shall be as specified in subparagraph 2.3.1.1. A unique numerical code designation shall be assigned to each hardware item. This numerical code shall reflect the hardware end item hierarchy, as shown in Figure 2.

2.3.1.1 Method of Subordination. One of two methods of subordination shall be employed, at the option of the contractor, to establish the hardware end item hierarchy:

a. Function-related. Assemblies, subassemblies, etc., which relate to the same general function (e.g., power supply, sample flow, amplifier) are listed together as separate subsystems.

b. Location-related. Items can be subordinated according to the grouping and layout of the items within the instrument. An example of location-related subordination would be main chassis top, subchassis on main chassis, tie point on subchassis, MSPs (i.e., resistors, capacitors, diodes, etc.) on tie point.

Found in Troubleshooting	Code						System Hardware Item	Reference Designator	Maintenance Function													Notes
									1	2	3	4	5	6	7	8	9	10	11	12	13	
									Adjust	Align	Calibrate	Checkout/Troubleshoot	Clean	Disassemble/Assemble	Inspect	Lubricate	Operate	Remove/Install	Repair	Service		
✓	1						Ozone Monitor		=	=	A	A	=	=	=	=	A	A	=	=		Mod.#5513340
																						Ser.#27369
	1	1					Power Supply Section		=	=	=	=	=	=	=	=	=	=	=	=		
✓	1	1	1				Switch, Power		=	=	=	=	=	=	=	=	=	A	=	=		
✓	1	1	2				Holder, Lamp	DS4	=	=	=	=	=	=	=	=	=	A	=	=		
✓	1	1	2	1			Lamp, Neon		=	=	=	=	=	=	=	=	=	A	=	=		
✓	1	1	3				Holder, Fuse		=	=	=	=	=	=	=	=	=	A	=	=		
✓	1	1	3	1			Fuse	F1	=	=	=	=	=	=	=	=	=	A	=	=		3A, SLO.BLO
✓	1	1	4				Transformer, Power		=	=	=	=	=	=	=	=	=	A	=	=		
✓	1	1	4	1			Diode	CR1	=	=	=	=	=	=	=	=	=	A	=	=		1N6484
✓	1	1	4	2			Diode	CR2	=	=	=	=	=	=	=	=	=	A	=	=		1N6484
✓	1	1	4	3			Capacitor	C6	=	=	=	=	=	=	=	=	=	A	=	=		10MF, 250 WVDC
✓	1	1	4	4			Capacitor	C7	=	=	=	=	=	=	=	=	=	A	=	=		10MF, 250 WVDC
✓	1	1	5				PC Board, 110 Volt Power															
							Supply		=	=	=	✓	=	✓	=	=	=	A	=	=		5511109
✓	1	1	6				Pump Fan Assembly		=	=	=	=	=	=	=	=	=	A	=	=		
✓	1	1	6	1			Reed Valve Assembly		=	=	=	=	=	=	=	=	=	A	=	=		
✓	1						Detector Cell Assembly		=	=	=	✓	✓	✓	=	=	=	A	=	=		
✓	1		1				PC Board, Electrometer															
							Amplifier		=	=	=	✓	=	✓	=	=	=	A	=	=		5511082

Figure 2. Example of a Preliminary Task Identification Matrix Page

2.3.1.2 Determination of Maintenance Significant Parts. The following guidelines shall be used in determining which hardware items constitute MSPs:

a. Normally, attaching hardware (e.g., screws, bolts) and knobs, grommets, washers, spacers, instrument feet, and similar miscellaneous small parts would not be considered as MSPs and would not be listed in the hardware end item hierarchy. Such items shall be included when operating conditions (e.g., high temperature or vibration) increase the likelihood of failure and such failure will affect the proper operation of the instrument.

b. Printed circuit boards, encapsulated assemblies, and other electronic components containing distinguishable parts which are not effectively repairable in the field shall be considered as MSPs.

c. Mechanical items containing distinguishable parts but which require special technical skills and/or equipment for repair shall be considered MSPs. Examples of this would be items which are factory evacuated/purged and sealed or which must be aligned using instrumentation not typically possessed by the procuring agency.

All decisions concerning MSPs are subject to approval during PTDR review.

2.3.2 Reference Designator. A reference designator distinguishes various identical equipment items in terms of their location and function within the instrument. For many instruments, reference designators are set forth in schematic diagrams.

2.3.3 Maintenance Function Entries (i.e., column headings). The following maintenance functions shall be the column headings of the matrix. They are defined in the Verb List, subsection 7.3.

a. Adjust
b. Align
c. Calibrate
d. Checkout/Troubleshoot
e. Clean
f. Disassemble/Assemble
g. Inspect
h. Lubricate
i. Operate
j. Remove/Install
k. Repair
l. Service

Other maintenance functions may be added to the above list from the Verb List. The column headings of the PTIM shall be assigned a code such as the numbers shown in Figure 2. All decisions concerning selection of maintenance function entries are subject to approval during PTIM review.

2.3.4 Level of Repair Entries (i.e., cell entries). For each intersection within the PTIM, entries shall be made, in the upper half of the cell, in accordance with the subparagraphs to follow.

2.3.4.1 Cell Entries. The following codes shall be employed to specify level of repair:

— – (dash) no maintenance task of this type is performed on this hardware item

A – a maintenance task of this type is performed by the procuring agency technicians

V – a maintenance task of this type is performed by the vendor or his representative, either at a service facility or in the field

2.3.4.2 Determination of Level of Repair. The vendor shall make every reasonable effort to minimize the number of maintenance tasks of type "V" in subparagraph 2.3.4.1. All "V" entries should be substantiated (see paragraph 2.3.6). All decisions concerning level of repairs are subject to procuring agency approval in the PTM review.

2.3.5 "Found in Troubleshooting." A checkmark entered in the "Found in Troubleshooting" column indicates that when this instrument hardware item malfunctions, the malfunction must be uniquely identifiable by troubleshooting procedures. The set of items with a check in this column represents a complete list of the components that are replaced or repaired as the result of troubleshooting. In most cases troubleshooting will be carried out on the total instrument. Occasionally, it may troubleshoot subsystems within the instrument separately, either in lieu of or in addition to instrument-level troubleshooting. Lower level checkout/troubleshoot tasks shall be identified by an "A" entry in the checkout/troubleshoot column, opposite the appropriate end item hierarchy entry or entries. Where multiple checkout/troubleshooting sequences are to be developed, the end item hierarchy shall show unambiguously which MBPs are to be isolated by which sequence(s).

2.3.6 Notes. The "notes" column may contain any information that would facilitate later stages of the manual development process. It may contain any or all of the following:

a. The fact that one of the tasks bears some special relationship to another task.

b. Substantiation for a "V" level of repair, i.e., the reasons why vendor maintenance is assumed to be required.

c. A further numerical identifier of the equipment item (e.g., manufacturer's part number) if necessary to uniquely and exactly specify the item.

d. The fact that one of the tasks is especially hazardous or difficult, or any fact that must not be omitted from subsequently prepared subproducts.

2.3.7 Review and Approval. The procuring agency may require that the Preliminary Task Identification Matrix be submitted by the vendor for review and approval. The approved Preliminary Task Identification Matrix shall identify the full population of instrument maintenance tasks and maintenance level at which each task is performed. Subsequent additions to, or deletions from, this population of tasks may be initiated by either the vendor or the procuring agency, but shall be approved by the procuring agency. Additional information concerning review and approval is contained in 6.1.

2.4 Test Equipment and Tool Use Form. This document provides detailed information on the use of test equipment and tools in conducting maintenance tasks. It shall be prepared by the vendor in accordance with the requirements that follow.

2.4.1 Classes of Information. The Test Equipment and Tool Use Form (TETUF) shall present the following classes of information for each tool and item of test equipment to be used in maintaining the instrument:

a. Name and number of item
b. Functions
c. Information to be included in the Instruction Manual
d. Prerequisite skills/knowledge, i.e., information to be given in training, or information that the agency technician is assumed to already know.

A suggested format for the presentation of this information is illustrated in Figure 3.

2.4.2 Name and Number of Item. Each item of test equipment and each special tool used in any maintenance task shall be listed. Common hand tools, the use of which will not be described in the Instruction Manual, may be grouped in a single entry. A model number or part number that distinguishes each item from every other shall be included with the item's name.

2.4.3 Functions. All functions for which each item of test equipment or special tool is used in the performance of maintenance tasks shall be listed opposite the name of each item.

TEST EQUIPMENT AND TOOL USE FORM

Name and Number of Item	Functions	Information to be Included in Manual	Prerequisite Skills/Knowledge
Multimeter, Simpson 260	Measure DC Voltage	1. Point of test will be stated in text and illustrated without pseudo test leads. 2. To establish polarity of points of test, the test leads" will be associated with the correct point of test. 3. The expected reading shall be stated as a range of acceptable values; e.g., check that the meter indicates ______ VDC or more. 4. The Manual will not normally contain specific range or function switch setting information. The user will be expected to know the appropriate setting of these controls given the expected reading. In situations where the reading is other than normal, the range information will be supplied to prevent test equipment damage.	1. Recognition of meter for use in making DC voltage measurements. 2. How to make range and function switch setting determinations. 3. How to read meter scales. 4. Any necessary safety precautions. 5. How to set up meter and make actual readings.

Figure 3. Sample Test Equipment and Tool Use Form

2.4.4 Manual Information. Opposite each function shall be listed the classes of information to be included in the manual whenever any of these functions is to be accomplished using the named item. The initial determination of what information is to be included shall be made on the basis of information provided by the Procuring Agency about the capabilities of the expected users of the manual (see subsection 1.5). Each entry concerning the class of information to be conveyed shall be followed by one or more standard statements that shows the words to be used whenever that class of information is to be conveyed. A standard statement has blanks that are used to fit the statement to specific circumstances. For example, "Check that multimeter reads ___ VAC or more" is a standard statement with a blank left for filling in specific voltage limits.

2.4.5 Prerequisite Information. Opposite each function shall be listed the classes of information to be given in training. In general, when considering tools and test equipment, the manual should tell the worker what to do, while the training should tell the worker how to do it and provide practice adequate to establish fluent performance.

2.4.6 Review and Approval. The procuring agency may require that the Test Equipment and Tool Use Form be submitted for review and approval (see 6.1).

2.5 TIM Annotated for Head/Book Tradeoff. Application of Head/Book Tradeoff Guidelines to the tasks identified in the Preliminary TIM will result in the TIM Annotated for Head/Book Tradeoff. The Head/Book determination shall be made for every "A" entry in the PTIM.

2.5.1 Row and Column Headings. The row and column headings for this matrix shall be identical to those specified in paragraphs 2.3.1 and 2.3.3.

2.5.2 Matrix Cell Entries. The possible cell entries shall be the following, made in the lower right half of each cell:

— - (dash) no maintenance task of this type is performed on the hardware item

H - performance of this task shall not be described in detail in the manual

B - performance of this task shall be described in the manual

2.5.3 Head/Book Tradeoff Guidelines. The following guidelines shall be employed in making the Head/Book Tradeoff determination:

a. Tasks in which the sequence of step performance is critical to the efficient, safe, and equipment-damage-minimizing performance of the task should be designated as "Book."

b. Tasks which involve complex, difficult-to-perform perceptions, discriminations, problem solving, decision making, and/or motor coordination should be designated as "Book."

c. Tasks which, if not correctly performed, are hazardous either to the technician or the equipment should be considered "Book."

d. Extremely long tasks, i.e., more than 10-12 steps, which are not highly iterative, are "Book" tasks.

e. Tasks which require the use of special tools and test equipment should be considered as "Book."

f. Tasks which the technician can perform correctly, based on brief inspection of the relevant end item(s) and without complications as noted in Guidelines a through e, may be considered as "Head." For example, since it is assumed that the user technician can solder/unsolder (see 1.5.5j), a task which only involves replacing a resistor need not be covered in the manual.

2.5.4 Review and Approval. Decisions concerning Head/Book Tradeoff are subject to procuring agency approval at its option, during TIM review (see 6.1).

3. JOB GUIDES DEVELOPMENT

3.1 Coverage. Job Guides shall be prepared to support all maintenance tasks identified by an "A/B" entry in the TIM, with the exception of Checkout/Troubleshoot. The information contained in the Job Guides will be based on the data sources and interim products determined in Section 2 of this specification.

3.2 Preliminary Information Worksheet (PIW). The vendor shall develop a Preliminary Information Worksheet for each Job Guide task in the TIM. The PIW serves two functions:

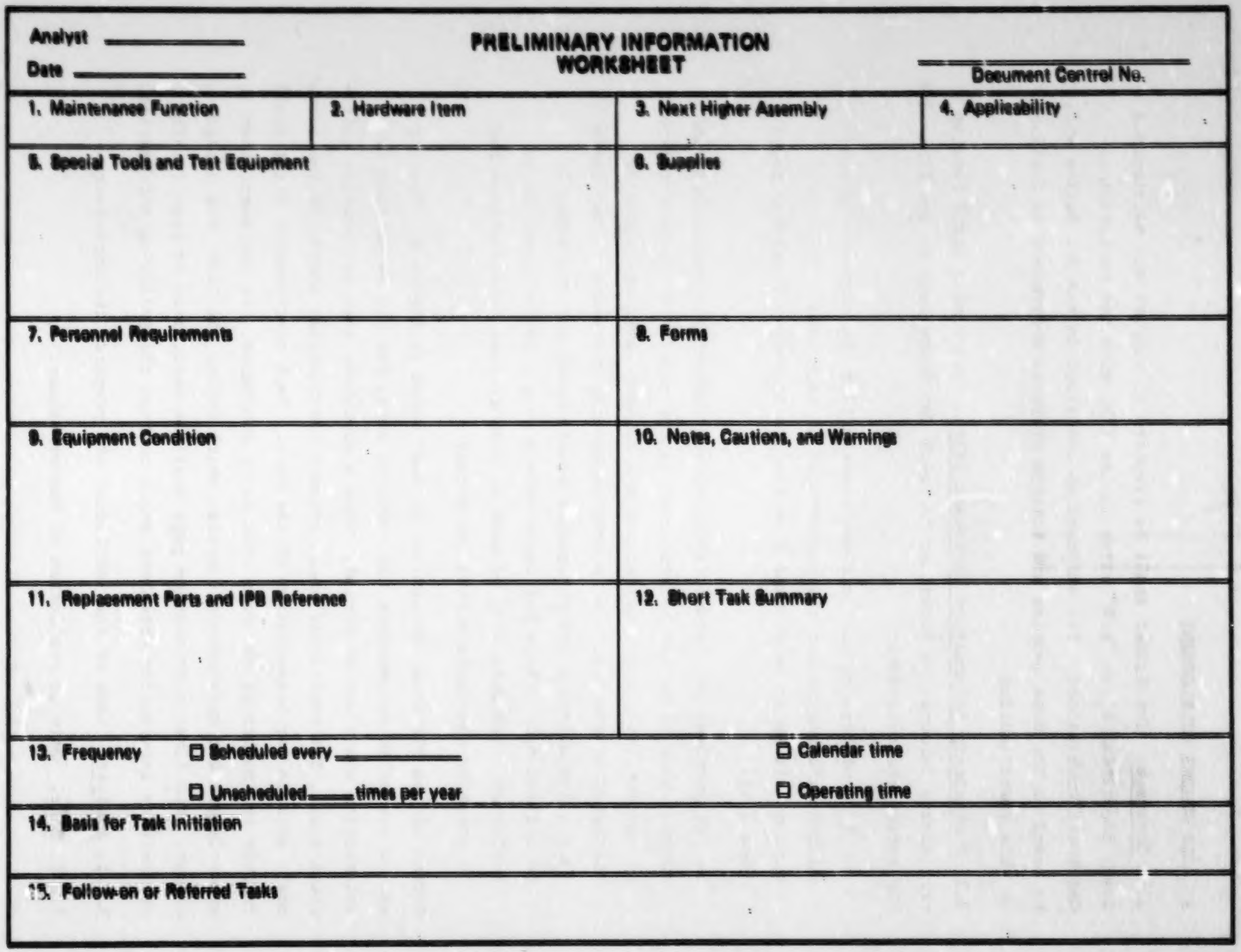
a. It consolidates onto one worksheet all of the necessary precondition information for the performance of each task. This information will later be presented on the preliminary information pages (see 3.4).

b. It provides for documentation of the interrelationships between tasks. Some tasks may be initiated as the result of the performance of another task, e.g., corrective maintenance tasks are normally initiated as the result of a troubleshooting procedure. Some tasks (e.g., installation and preventive maintenance) may not normally be initiated by others but cause others (e.g., calibration) to be performed. The data will be used to prepare task introductions and to organize the tasks within the manual.

Format of the PIW shall be similar to that shown in Figure 4. Spacing may be varied to accommodate the required data, but the sequencing of information shall not be varied. When a worksheet does not provide sufficient space, the contractor shall prepare continuation sheets in the format most suitable for presentation of the data. Each continuation sheet shall include the number of the data item being continued, the equipment item nomenclature and maintenance function which define the task, and a page number. The first continuation page shall be designated as page 2. The preliminary information worksheet shall contain the following information.

3.2.1 Analyst. Name of the individual who prepares the worksheet.

3.2.2 Date. Date of completion of the worksheet.



Analyst ____________

Date ____________

PRELIMINARY INFORMATION WORKSHEET

____________ Document Control No.

1. Maintenance Function	2. Hardware Item	3. Next Higher Assembly	4. Applicability
5. Special Tools and Test Equipment		6. Supplies	
7. Personnel Requirements		8. Forms	
9. Equipment Condition		10. Notes, Cautions, and Warnings	
11. Replacement Parts and IPB Reference		12. Short Task Summary	

13. Frequency ☐ Scheduled every ____________ ☐ Calendar time

☐ Unscheduled ____ times per year ☐ Operating time

14. Basis for Task Initiation

15. Follow-on or Referred Tasks

Figure 4. Preliminary Information Worksheet

3.2.3 Maintenance Function. One of the column headings of the task identification matrix, as listed in 2.3.3.

3.2.4 Hardware Item. One of the row headings of the task identification matrix, as defined in 2.3.1. This will include nomenclature and part number.

3.2.5 Next Higher Assembly. The nomenclature and part number of the next higher assembly upon which the subject item is installed.

3.2.6 Applicability. The applicability of the data on this worksheet to specific models or configurations within models. If the data is applicable to all configurations, the word "all" shall be entered.

3.2.7 Special Tools and Test Equipment. The tools and test equipment, listed in accordance with 2.4, that are used in the subject task other than common hand tools. Common name, specific name, and part number shall be indicated for each tool or item of test equipment.

3.2.8 Supplies. All expendable items, consumable items, and nonaccountable replacement parts that are customarily brought to (or are available at) the task site. Some examples of supplies are sealants, lubricants, replacement lamps, labels, safety wire, gaskets, electrical tape, "maintenance in progress" tags, data sheets, calibration curves, and conversion tables.

3.2.9 Personnel Requirements. A narrative description of the number of men required to perform the task, their qualifications, and their role in the accomplishment of the task. If communication is required, typical frequency and means of communication shall be stated.

3.2.10 Forms. Any forms that the technician needs to fill out during task performance, as well as the source of instructions for filling them out.

3.2.11 Equipment Condition. The state or condition of the equipment that must exist before the task can be performed on it. For example, the equipment may have to be warmed up or calibrated before the task can be initiated.

3.2.12 Notes, Cautions, and Warnings. "Notes" highlight the task aspects or steps that are vital to correct task accomplishment. "Cautions" refer to practices which prevent or preclude instrument damage and/or inaccuracy. "Warnings" speak of safety hazards and how personal injury can be avoided or prevented. The entries under this heading will include all general cautions, warnings, and notes which, if not observed, could cause loss of instrument effectiveness, personal injury, or serious instrument damage. They apply to precautions that need to be made clear before a task is begun and to factors to be kept in mind throughout task performance.

3.2.13 Replacement Parts and IPB Reference. A listing of any parts that may be required during accomplishment of the task. Each part shall be identified by nomenclature and number, and referenced to the applicable figure in the Illustrated Parts Breakdown (IPB) should an IPB be employed as a data source.

3.2.14 Short Task Summary. A concise technical description of what the task accomplishes and the means that are employed.

3.2.15 Frequency. Indicate whether the task is accomplished on a scheduled or an unscheduled basis. If the task is unscheduled, indicate the approximate number of times per year that this task would normally be performed. If the task is scheduled, indicate the scheduled interval (number of hours, days, weeks, etc.). Indicate also whether the maintenance interval is stated in terms of calendar time or operating time.

3.2.16 Task Initiation. Indicate the task type by using one of the following codes:

C – corrective maintenance task (unscheduled)

O – operational task (i.e., operation, calibration, installation)

P – scheduled task (i.e., preventive maintenance)

Indicate whether the task is normally initiated as a result of performing some prior task. Identify the task that is performed prior to the subject task. If there are many such tasks, continue the list on a continuation sheet. Indicate the precise basis for task initiation, such as the malfunction symptom that establishes the need for this task to be performed.

3.2.17 Follow-On Tasks. Identify those tasks which must be performed after the subject task. Some tasks are not complete work units in themselves. When the goal of the task has been achieved, the instrument cannot be left in its current condition. The tasks required to return the equipment to a ready state or to a safe condition shall also be listed in this item.

3.2.18 Notes. Any information that should be provided to facilitate the understanding of the data items on the worksheet shall be entered on the reverse side of the sheet.

3.3 Detailed Step Description Worksheet. This worksheet shall be used for recording a step-by-step description of each Job Guide task. The emphasis should be on compiling all data that will be needed to develop the narrative text and illustrations for the Job Guide. It shall present information keyed to the task steps. The format of this worksheet shall be similar to that shown in Figure 5. The task steps shall be at a level of detail appropriate to the intended audience (see subsection 1.5). They shall be complete, accurate, and in correct sequence. The data items that shall be included on this worksheet are the following.

3.3.1 Analyst. Name of the individual who prepares the worksheet.

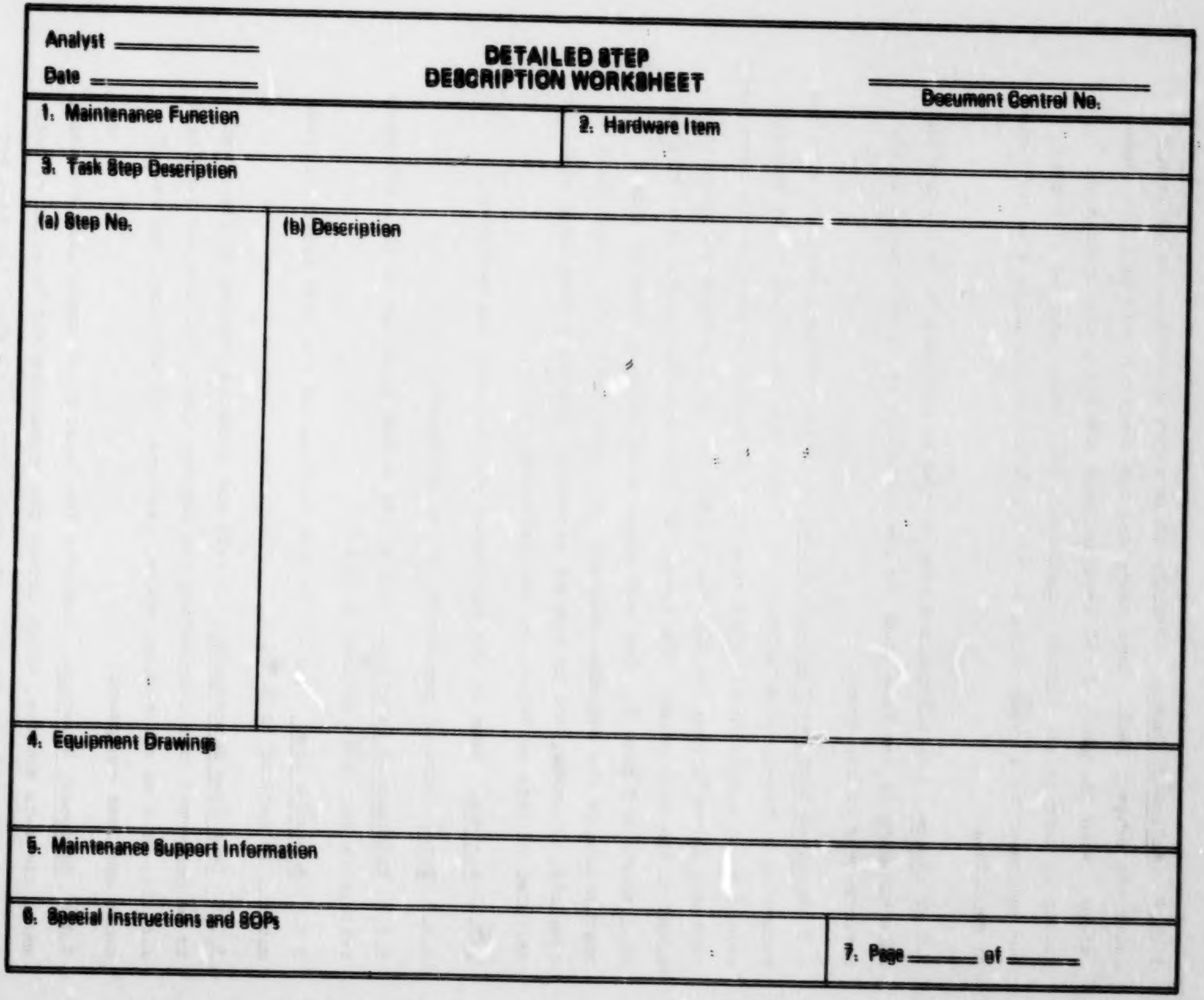
3.3.2 Date. Date of completion of the worksheet.

3.3.3 Maintenance Function. One of the column headings of the task identification matrix as defined in 2.3.3.

3.3.4 Hardware Item. One of the row headings of the task identification matrix, as defined in 2.3.1.

3.3.5 Task Step Description. A full and accurate listing of the steps to be performed in accomplishing the subject task. Include all technical details, such as tolerances, notes, cautions, and warnings, and use of tools and test equipment.

3.3.6 Equipment Drawings. Indicate the location of applicable drawings, among the data sources, which convey the appearance and location of both the work site and the specific equipment items with which the task performer must interact. Identify the location of any relevant general-locator



Analyst ____________

Date ____________

DETAILED STEP
DESCRIPTION WORKSHEET

____
Document Control No.

1. Maintenance Function

2. Hardware Item

3. Task Step Description

(a) Step No.

(b) Description

4. Equipment Drawings

5. Maintenance Support Information

6. Special Instructions and SOPs

7. Page ______ of ______

Figure 5. Detailed Step Description Worksheet

drawings, item enlargements, and exploded-view drawings. Include file numbers of all illustrations created to accompany the detailed step description text.

3.3.7 Maintenance Support Information. Any instructions or reference information that are not appropriate for inclusion as steps in the task shall be identified and referenced for use in the generation of notes, cautions, and warnings. The step or steps to which this additional information is most applicable shall be indicated.

3.3.8 Special Instructions and Standard Operating Procedures. Those steps which require special instructions, such as how to perform a leak test, or which are performed in accordance with standard operation procedures (e.g., EPA reference methods) shall be identified, and the source of such instructions shall be referenced or the data shall be entered.

3.3.9 Page Number. Indicate page number in the form "Page __ of __."

3.4 Input Conditions Pages. An Input Conditions Page shall be developed from the data provided on the Preliminary Information Worksheet (see 3.2), for each Job Guide. The major emphasis during the development of the Input Conditions Pages is the determination of task grouping to form each activity, i.e., each Job Guide, as defined in 3.4.1. The Input Conditions Page is the first page in the Job Guide and contains items of information as described in 3.4.2 through 3.4.11. The format shall be as shown in Figure 6.

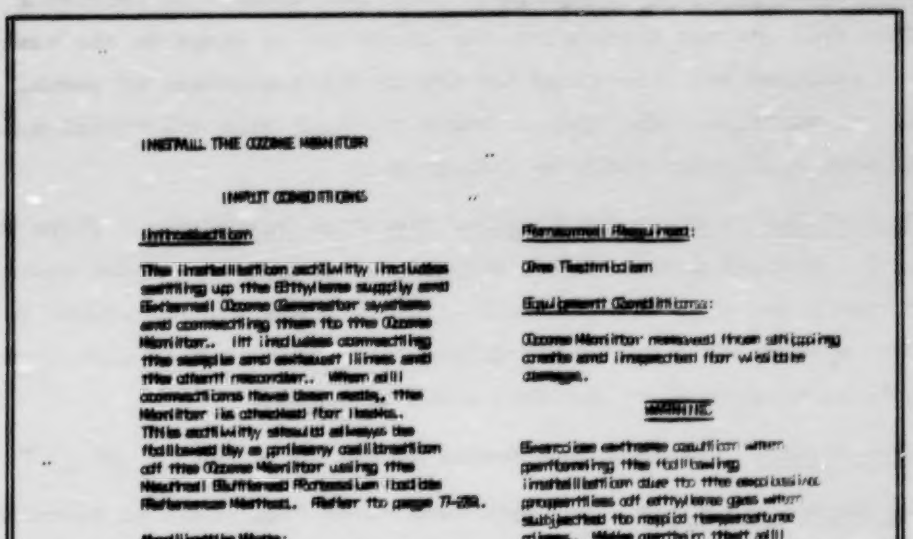
3.4.1 Activity Defined. An activity shall consist of one of the following:

a. A single maintenance task.

b. A group of tasks that are usually performed in the same sequence (e.g., remove, repair, install).

c. One or more tasks with references to other activities.

A common example of alternate c is where the same series of covers and panels may have to be opened or removed to gain access to several items. The repetition of one procedure many times only adds to the amount of textual material with which the experienced technician must cope.



INSTALL THE OZONE MONITOR

INPUT CONDITIONS

Introduction

This installation activity includes setting up the Ethylene supply and External Ozone Generator systems and connecting them to the Ozone Monitor. It includes connecting the sample and exhaust lines and the chart recorder. When all connections have been made, the Monitor is checked for leaks. This activity should always be followed by a primary calibration of the Ozone Monitor using the Neutral Buffered Potassium Iodide Reference Method. Refer to page II-28.

Applicable Mode:

All

Special Tools and Test Equipment:

12" Adjustable Wrench
Two 7/16" Open End Wrenches
Two 1/2" Open End Wrenches
Two Support Stands
Three Utility Clamps

Supplies:

Liquid Leak Detector Solution
100 ft. Rubber Tubing, Thick Walled,
  1/4" I.D., or equivalent
Ethylene Cylinder
Air Cylinder or Air Pump

Personnel Required:

One Technician

Equipment Conditions:

Ozone Monitor removed from shipping crate and inspected for visible damage.

WARNING

Exercise extreme caution when performing the following installation due to the explosive properties of ethylene gas when subjected to rapid temperature rises. Make certain that all connections are mated properly so that gas leakage does not occur.

CAUTION

Avoid use of Tygon tubing in the Sample Introduction and Calibration Sample Systems.

II-1

Figure 6. Example of Format for Preliminary Information Page

In situations where identical task steps are required to gain access to several different components in different tasks within a volume, the access information may be written out completely as a separate task in the volume and referenced in the other tasks, as necessary. These references shall appear in either:

a. The Equipment Conditions section of the Preliminary Information page,

b. A note in the procedure, or

c. A task step of the procedure.

Closing-up procedures shall be developed in the same fashion as access information. To the extent that closing-up procedures are not exact reversals of their access procedure, such procedures shall be developed as separate tasks.

3.4.2 Section Heading. The name of the section (e.g., Installation, Calibration) shall appear at the top of the page.

3.4.3 Activity Title. The activity title shall appear in capital letters below the section heading. Activity titles shall specify the type of maintenance to be performed (e.g., replace, inspect, adjust) and the hardware item that is to receive the maintenance.

3.4.4 Introduction. A brief introductory statement shall follow the Section Heading and shall state the objective(s) of the activity, a description of the operation(s) to be performed, and possible antecedent events (i.e., other tasks or troubleshooting procedures which may have led the technician to this particular point). Where there are many tasks in one activity and where there is more than one possible sequence of tasks, the conditions dictating each sequence shall be stated. If any task is a scheduled maintenance task, the introduction shall include the interval between occurrences and other conditions which dictate the performance of the task.

3.4.5 Applicable Serial (Model) Numbers. The serial number ranges or model numbers of the various equipment configurations to which the activity is applicable shall be stated. If the instructions apply to all configurations, the word "all" shall be entered.

3.4.6 Special Tools and Test Equipment. All test equipment and special tools not listed as common hand tools in the TEMF (see subsection 2.4) shall be identified. The special tools and/or test equipment needed for the performance of the maintenance activity shall be listed, including specific name and part number.

3.4.7 Supplies. Expendable items and support materials shall be listed. Sealants, lubricants, replacement lamps, labels, "maintenance in progress" tags, etc., are considered expendable items. When the item can be identified by a part number, the number shall be given. The quantity and size, when applicable, of each expendable item required to complete the task shall also be given.

3.4.8 Personnel Required. The minimum number of personnel required to perform the task shall be stated. The number may include the primary technician and one or more assistants (to whom verbal instructions will be communicated by the primary technician), or several technicians for whom individual instructions are provided separately in the manual. Following the statement of number of personnel shall be statements of the task starting position (relative to the instrument) of each technician and assistant. Technicians shall be designated Man A, Man B, etc.

3.4.9 Equipment Conditions. Certain activities are dependent upon the instrument being in a given condition (e.g., stabilized and calibrated). These required conditions shall be stated. Any information pertinent to safety shall also be included and presented as a caution or warning. When the required conditions can be obtained by performing other maintenance tasks, those tasks shall be indicated as prerequisites and shall be referenced by page number. Any warnings, cautions, or notes applicable to the entire task shall be included.

3.4.10 Activity Index. Occasionally, it will be desirable to divide the activity into two or more tasks (e.g., where an "install" procedure is not a simple reversal of its corresponding "remove" procedure). The activity index shall be a listing of all such maintenance tasks that are included within the activity and the corresponding page numbers on which they start. The names of the tasks shall be included on the left side under the heading, "Procedure." The corresponding page numbers shall be on the right side under the heading, "Page."

3.4.11 Replacement Parts. When replacement parts (other than expendible items and supplies) are required by a procedure, the parts shall be listed by name, number, and illustration frame reference designator number.

3.5 Narrative Text. Narrative Text shall be prepared, based on the Detailed Step Description Worksheets, for each Job Guide. The emphasis in this activity is to modify the draft materials as necessary to assure that all writing requirements (see 5.4) have been met. The text shall consist of a group of task steps which are to be performed in an indicated order. Each hardware item mentioned in the body of the task steps shall be accompanied by a callout number, in parentheses, keyed to an illustration of that item. The following types of task steps shall be used as needed:

a. Linear Task Step - Linear task steps are task steps which are performed in a fixed sequence (i.e., task step x is always followed by task step y).

b. Branching Task Step - Branching task steps contain measurement or observation procedures which, by their outcome, determine the next task step to be performed (i.e., step x may be followed by step y or step z depending upon the results of the check at step x). When a test instrument is involved, the name of the instrument and the type of measurement to be made shall be included in the instruction.

c. Reference Step - Reference Steps direct the technician to branch to a specific page or frame of the volume.

d. Notes, Cautions, and Warnings Paragraphs - These paragraphs contain comments that emphasize important and critical conditions to which the technician should attend, as well as the corresponding action implications.

e. Terminal - Task steps which complete the maintenance activity

3.6 Illustrations. An illustration shall be developed for every hardware item referred to in the text. Locator illustrations and exploded views shall also be developed, as required. Illustrations shall be prepared in accordance with 5.5. See also 4.6.1.

3.7 Formatting. For each Job Guide narrative text and associated illustrations will be combined to make up one or more instruction frames. The frame is the basic unit of the maintenance instruction information presentation. A frame shall consist of two facing pages with step-by-step narrative text and associated illustrations (see Figures 7, 8, and 9).

3.7.1 Page Size. Page size and layout shall be as specified in Figure 10 and subsection 5.2.

3.7.2 Frame Arrangement. Within the two facing frame pages text and illustrations shall be arranged to make maximum use of the available space while adhering to the writing and illustrating requirements of 5.4 and 5.5. The following guidelines shall apply to arrangement of text and illustrations:

a. Text shall be presented in columns 3-1/4 inches wide. Either one or both columns on a page may be occupied by text (see Figure 7).

b. The left-hand column of the left-hand page shall begin with the title of the activity. If the activity is composed of more than one task, the appropriate task title shall follow the activity title. Task steps shall follow, numbered consecutively from the beginning to the end of the activity.

c. If a column is only partially filled with text, the text shall begin at the top of the page, and the space below the termination of text may be occupied by illustration.

d. Illustrations may occupy any space not occupied by text.

e. Although both text and illustrations may occupy both of the pages in a frame, it is permissible for either page to be wholly occupied by either text or illustrations alone.

f. The text on either page may refer to illustrations on either page.

g. The illustrations shall, whenever space permits, be presented so that illustrations follow order of appearance in the text in a roughly left-to-right and top to-bottom manner across the two pages of the maintenance instruction frame.

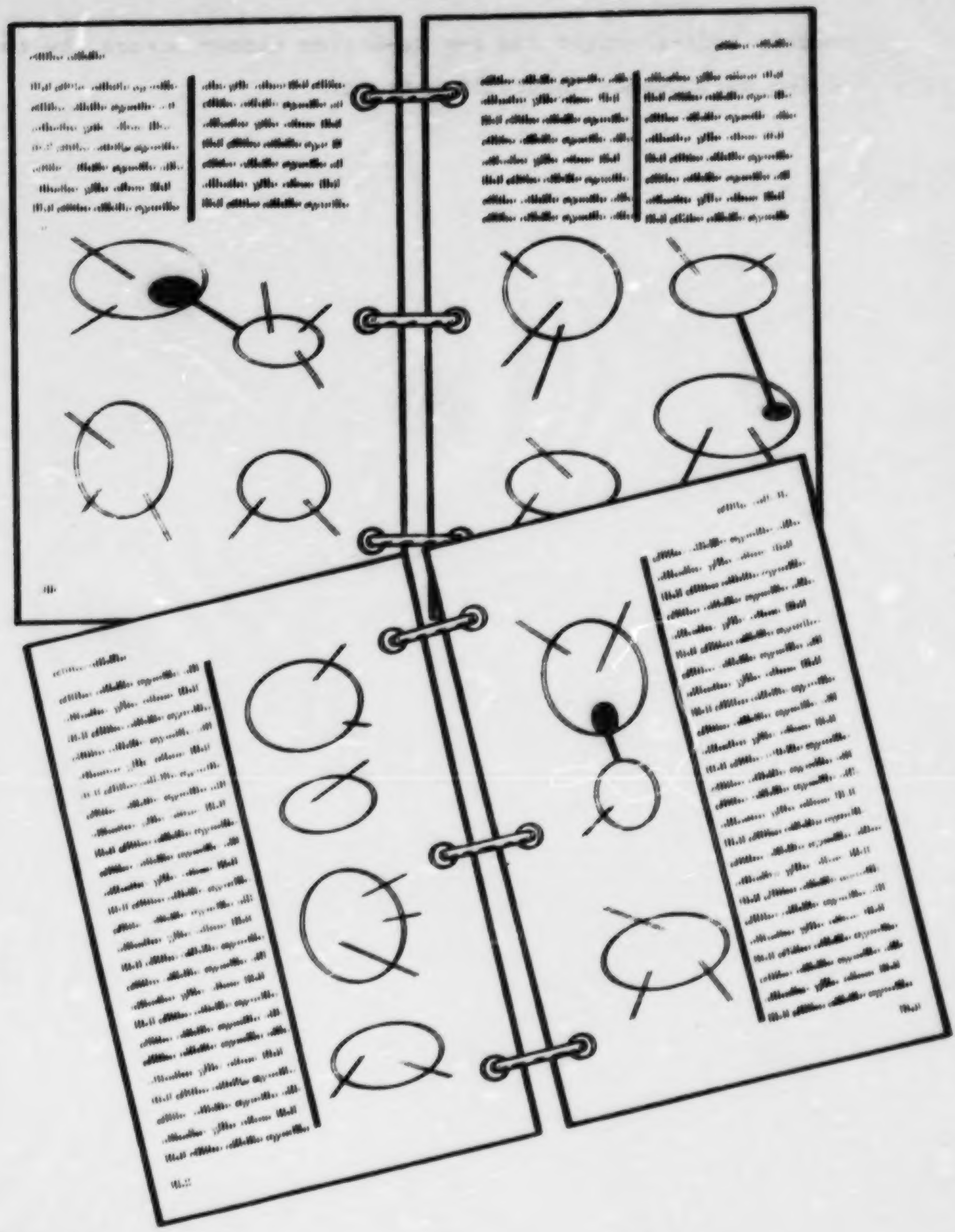


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Figure 7. Example of Allowable Maintenance Frame Arrangements

INSTALL THE OZONE MONITOR

9. Slowly open ethylene cylinder valve (13) fully counterclockwise.

10. Adjust ethylene regulator control (7) to obtain output pressure of 30 psi.

11. Adjust ETHYLENE control (4) to pressure indicated on supplied data sheet.

NOTE

On Model 4001, ETHYLENE pressure control is located external to Ozone Monitor. After adjusting ETHYLENE pressure control, rotate ETHYLENE flowmeter valve on Ozone Monitor fully counterclockwise.

12. Check all ethylene plumbing connections for leaks using leak detector solution. Repair or replace any defective ethylene fittings.

13. Set MODE SELECTOR switch (1) to ZERO.

14. Rotate SAMPLE PLUS ETHYLENE needle valve (3) counterclockwise until an airflow is indicated on flowmeter (5).

15. Seal off air flow at Calibration Sample Filter inlet (8). Check that SAMPLE PLUS ETHYLENE flowmeter (5) slowly decreases to 0. If not, a leak exists between Calibration Sample Filter (8) and SAMPLE PLUS ETHYLENE flowmeter (5). Refer to Leak Detection Procedure, Section 7.

16. Open Calibration Sample Filter inlet (8).

17. Set MODE SELECTOR switch (1) to AMBIENT.

18. Using finger or a plug, seal off air flow at SAMPLE INLET fitting (9). Check that SAMPLE PLUS ETHYLENE flowmeter (5) slowly decreases to 0. If not, a leak exists between SAMPLE INLET fitting (9) and SAMPLE PLUS ETHYLENE flowmeter (5). Refer to Leak Detection Procedure, Section 7.

19. Open Sample Inlet fitting (9).

20. Rotate ethylene pressure regulating control (7) fully counterclockwise.

21. Rotate ethylene cylinder valve (13) fully clockwise.

22. Set POWER switch (2) to off.

23. Install top cover (11) with four screws (10).

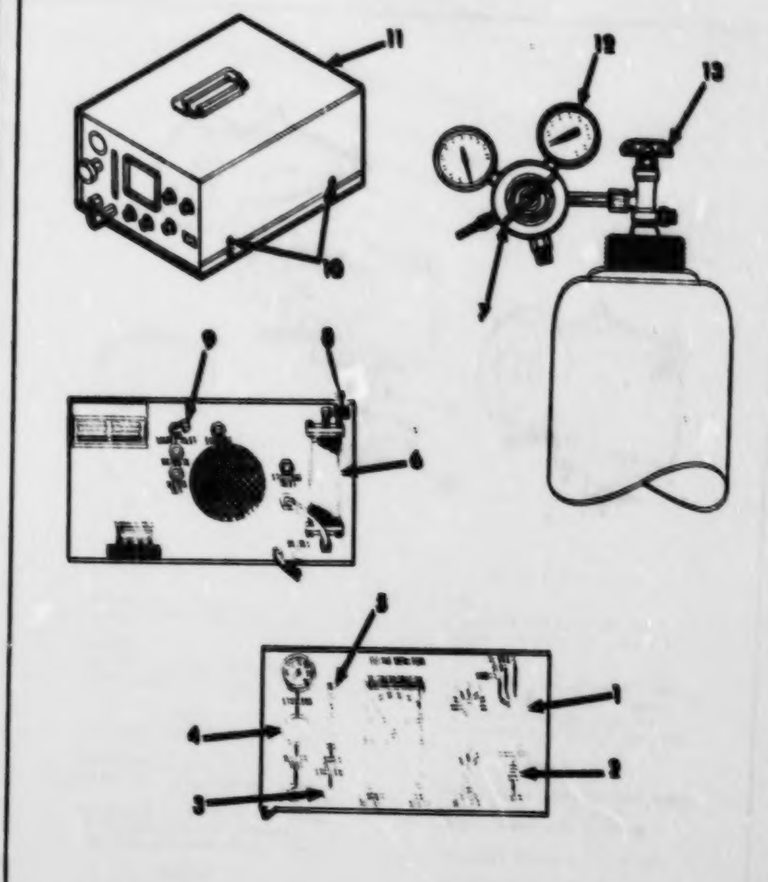

Figure 8. Format for Maintenance Instruction Frame - Example 1

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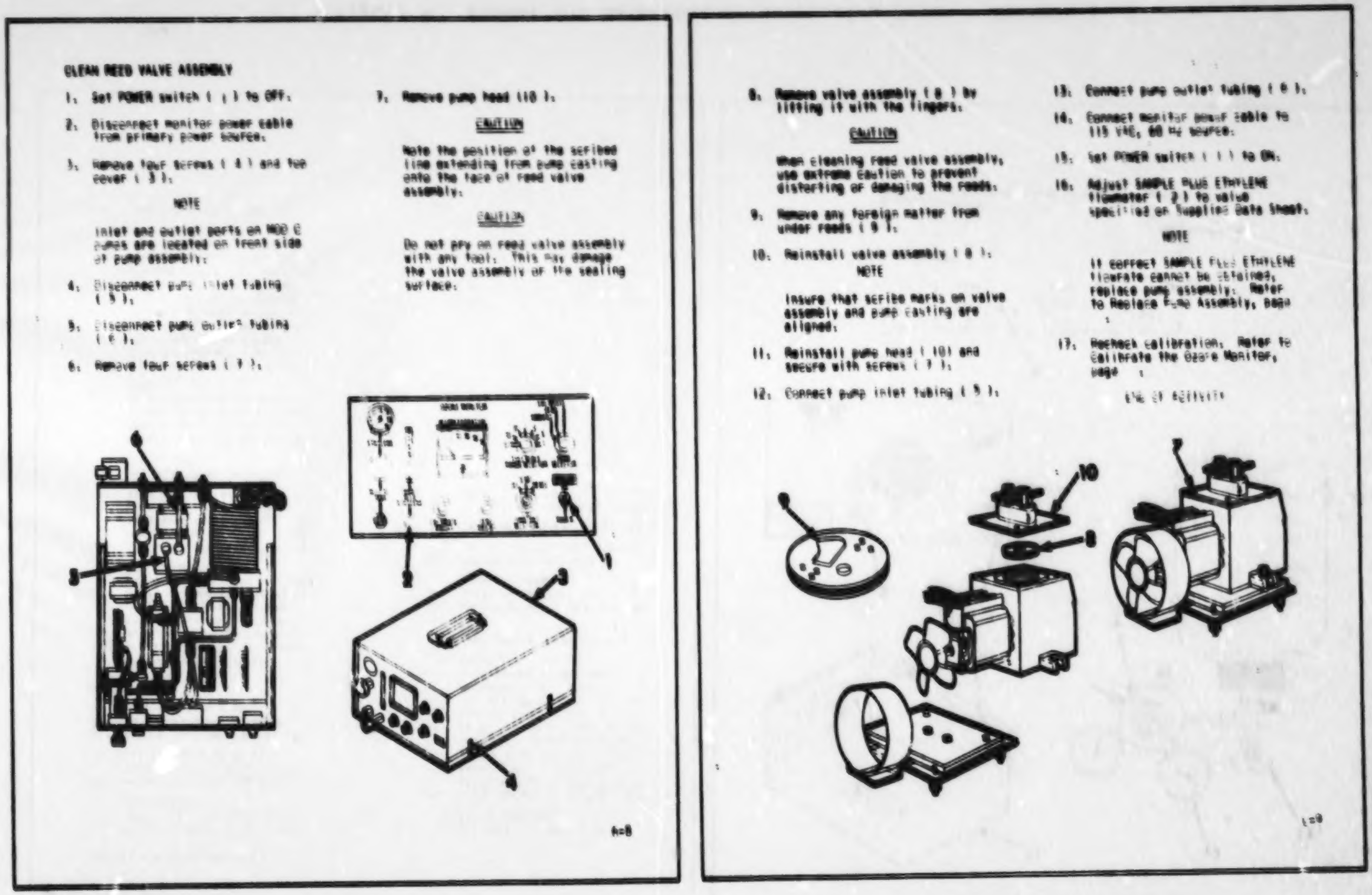


CLEAN REED VALVE ASSEMBLY

1. Set POWER switch (1) to OFF.
2. Disconnect monitor power cable from primary power source.
3. Remove four screws (4) and the cover (3).

NOTE

Inlet and outlet ports on MOD E pumps are located on front side of pump assembly.

4. Disconnect pump inlet tubing (5).
5. Disconnect pump outlet tubing (6).
6. Remove four screws (7).
7. Remove pump head (10).

CAUTION

Note the position of the scribed line extending from pump casting onto the face of reed valve assembly.

CAUTION

Do not pry on reed valve assembly with any tool. This may damage the valve assembly or the sealing surface.

A-8

8. Remove valve assembly (8) by lifting it with the fingers.

CAUTION

When cleaning reed valve assembly, use extreme caution to prevent distorting or damaging the reeds.

9. Remove any foreign matter from under reeds (9).
10. Reinstall valve assembly (8).

NOTE

Insure that scribe marks on valve assembly and pump casting are aligned.

11. Reinstall pump head (10) and secure with screws (7).
12. Connect pump inlet tubing (5).
13. Connect pump outlet tubing (6).
14. Connect monitor power cable to 115 VAC, 60 Hz source.
15. Set POWER switch (1) to ON.
16. Adjust SAMPLE PLUS ETHYLENE flowmeter (2) to value specified on Supplier Data Sheet.

NOTE

If correct SAMPLE PLUS ETHYLENE flowrate cannot be obtained, replace pump assembly. Refer to Replace Pump Assembly, page .

17. Recheck calibration. Refer to Calibrate the Ozone Monitor, page .

END OF ACTIVITY

A-9

Figure 9. Format for Maintenance Instruction Frame - Example 2.

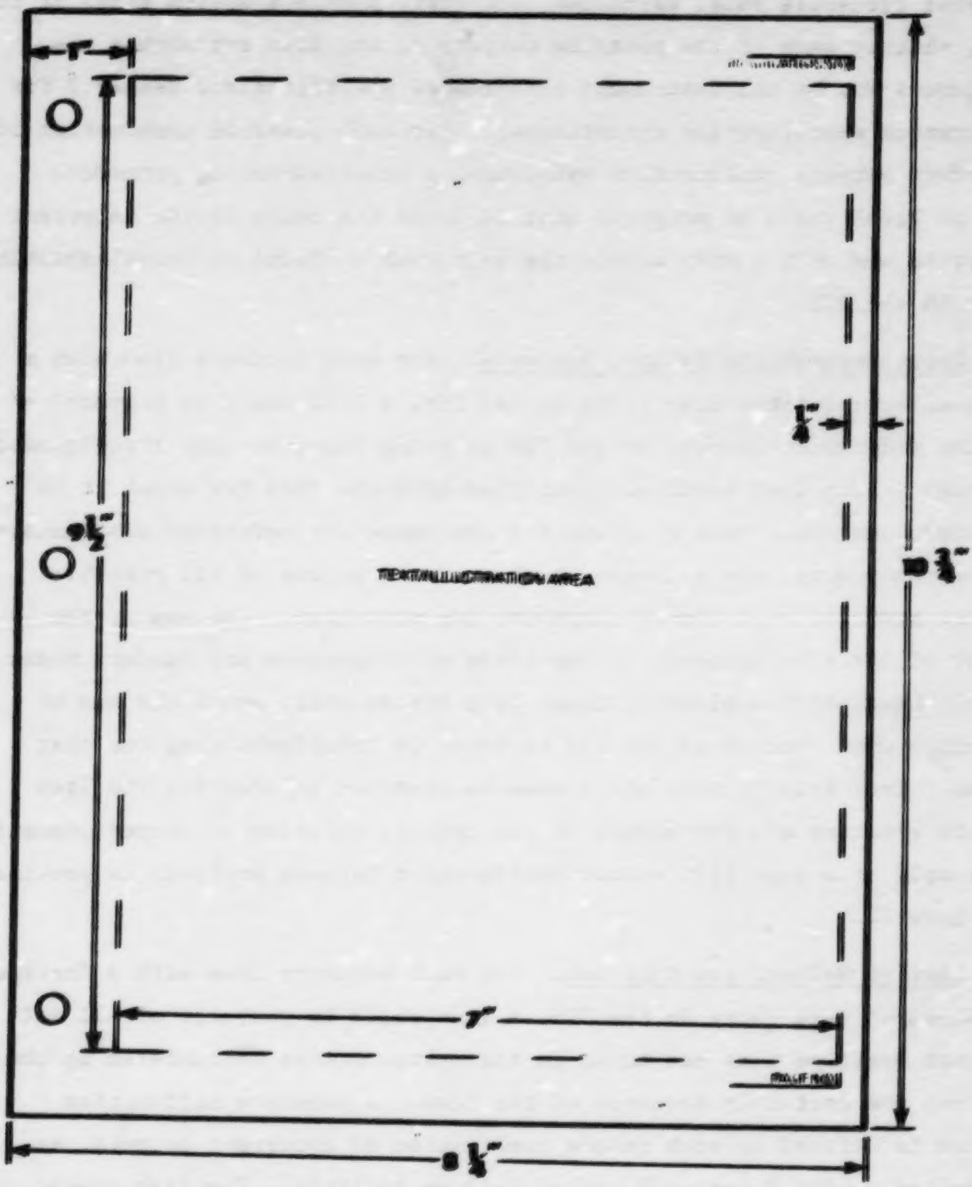

1"
9 1/2"
1/4"
10 3/4"
TEXT/ILLUSTRATION AREA
7"
8 1/2"

Figure 10. Page Layout

4. TROUBLESHOOTING AIDS DEVELOPMENT

4.1 Coverage. A Checkout Procedure shall be developed for each hardware item in the TIM with an entry in the Checkout/Troubleshoot column. Each Checkout Procedure shall establish, for every possible system state of the item, whether each of the possible outputs of the item are within the tolerances set by the instrument performance specifications (see 7.2 for performance specification definitions). For each possible combination of incorrect outputs (malfunction symptoms), a troubleshooting procedure (Action Tree) shall be prepared that isolates the cause of the incorrect output to one of the MSPs within the unit with a "Found in Troubleshooting" entry in the TIM.

4.2 Function/Function Failure Analysis. For each hardware item with a Checkout/Troubleshoot task entry in the TIM, a list shall be prepared of all the components checked in the TIM as being found by that troubleshooting task. Each list shall be identified with the item for which it is prepared, and shall have a column for the names and reference designators of the components, and a column in which descriptions of all possible failure modes of each listed component are presented. The sum of the number of listed components in the Lists of Components and Failure Modes for all Checkout/Troubleshoot tasks in a system shall equal the sum of all components checked in the TIM as found in troubleshooting for that system. Each failure mode shall then be examined to identify the item outputs affected and the nature of the change, relative to proper operation. An example of a page from a function/function failure analysis is provided as Figure 11.

4.3 List of Malfunction Symptoms. For each hardware item with a Checkout/Troubleshoot task entry in the TIM, a list shall be prepared of all malfunction symptoms that can occur in the system states encountered in the start-up and operating sequence of the item. A separate malfunction sympton is defined by each unique combination of incorrect outputs, as determined by the Function/Function Failure Analysis. The list should specify:

a. A complete description of each malfunction sympton, including all affected outputs and the nature of their changes.

FUNCTION/FUNCTION FAILURE ANALYSIS FORM

Item Ozone Monitor

Analyst P. Koleski

Date 9/10/73

Component Name	Reference Designator	Related Outputs	Failure Modes	Outputs Effected and Nature of Change
Capacitor	C6	O_3 meter AC power indicator	OPEN	1. O_3 meter does not deflect properly. 2. Deflects to right.
			Shorted	If load is excessive F1 opens and power on indicator does not light.
			Decrease in value	O_3 meter does not deflect properly
Capacitor	C7	O_3 meter AC power indicator	Open	O_3 meter does not deflect properly (deflects to right)
			Shorted	If load is excessive F1 opens and power on indicator does not light
			Decrease in value	O_3 meter does not deflect properly
110 VDC Regulator PC Board		O_3 meter AC power indicator	Pin 1 open	O_3 meter deflects to left (+110 VDC low)
			Pin 1 shorted	F1 opens and power on indicator does not light
			Pin 2 open	O_3 meter deflects to right (-110 VDC low)
			Pin 2 shorted	F1 opens and power on indicator does not light
			Pin 9 open	O_3 meter deflects to right (+110 VDC high)
			Pin 9 shorted	O_3 meter deflects to left (+110 VDC shorted but card contains a current limiter)

Figure 11. Example of Completed Function/Function Failure Analysis Form

b. A designation of all MSPs which could produce such a malfunction symptom.

4.4 Checkout Procedure. A Checkout Procedure shall be prepared for each hardware item with a Checkout/Troubleshoot task entry in the TIM. A Checkout Procedure shall consist of a straight-line checkout plus branching procedures that complete malfunction symptom identification.

4.4.1 Purpose. The purposes of the Checkout Procedure are:

a. To systematically manipulate the hardware item under test and perform measurements that permit observation of any malfunction symptom present.

b. To reference the appropriate Action Tree for troubleshooting, if a malfunction symptom is observed.

c. To determine that the system is completely operational after fault has been identified and corrected.

4.4.2 Straight-Line Checkout. A Checkout Procedure shall begin with a straight-line sequence of task steps that examine each active output of the hardware item, following the sequence of system states as they occur in the start-up and operating sequence for the item. For each subsequent system state, only changed or added active outputs shall be checked. Factors affecting checkout step sequence shall be:

a. Checks that take advantage of front-panel indicators and built-in test equipment (BITE) should appear earlier in the sequence than checks requiring connection of external test equipment to examine outputs.

b. Active outputs common to more than one system state may be checked at the most cost-effective time, as determined by test equipment requirements, test point accessibility, location of the technician, and reliability information.

Successful completion of the straight-line check sequence without discovery of any negative check results shall require demonstration of proper operation of all active outputs in all operational system states.

Successful completion of each step in the straight-line sequence shall lead to the next step; a negative outcome shall include a reference to another part of the procedure where the symptom pattern will be completed.

4.4.3 Symptom Pattern Completion. The straight-line check sequence shall be followed by a series of branching procedures that allow completion of the symptom pattern following a negative outcome of each check in the straight-line sequence. Considering an observed negative outcome at a particular point in the straight-line sequence as the first element of the symptom pattern, each branching procedure shall continue examining active outputs until it has provided for complete identification of each possible symptom. A reference to an action tree shall appear at each point in the procedure at which a malfunction symptom is identified.

4.4.4 Coverage. The complete checkout procedure shall contain checks of all active outputs of the hardware item under test and shall identify each malfunction symptom in the List of Malfunction Symptoms for that item.

4.5 Action Trees. For each malfunction symptom that is identified, a troubleshooting procedure (Action Tree) shall be prepared that isolates the malfunction to one of the hardware items on the list of components and failure modes for the Checkout/Troubleshoot task. Each Action Tree shall isolate every component failure mode that can produce the related malfunction symptom.

4.5.1 The Component Block Diagram. If there is an existing energy flow diagram (schematic representation of functional relationships among components in the system), such a diagram may be used. If such a diagram is not available, a schematic diagram shall be prepared that depicts the energy flow relationships among all of the components listed as possible causes of the malfunction symptom for which the Action Tree will be prepared.

4.5.2 Information Requirements. Action Trees shall contain the following types of steps:

a. Procedural steps, directing the performance of an operation for which no decision is required.

b. Repair or replacement steps, which direct the repair or replacement of one of the components on the list of components and failure modes. The component to be repaired or replaced shall be identified by its official nomenclature and reference designator.

c. Test/Decision steps, in which diagnostic tests are made, the possible outcomes stated, and the action to be taken as a result of each outcome specified. The following requirements apply:

(1) Name and model number of test instrument (if any) shall be stated.

(2) Type of reading shall be stated (e.g., pressure, voltage).

(3) Location of test points shall be stated.

(4) Range of acceptable values for the reading shall be stated.

(5) Action to take as result of each possible outcome of the check shall be stated.

(6) Only two possible outcomes are permitted in a single test/decision step. If a single test or measurement can have more than two outcomes that have different diagnostic implications, then additional decision steps shall be provided, each with only two possible outcomes. For example, if the acceptable range for a resistance reading is 50 to 75 ohms, and if a low out-of-tolerance reading implies a different fault from a high out-of-tolerance reading, then two steps must be written, with the following general form:

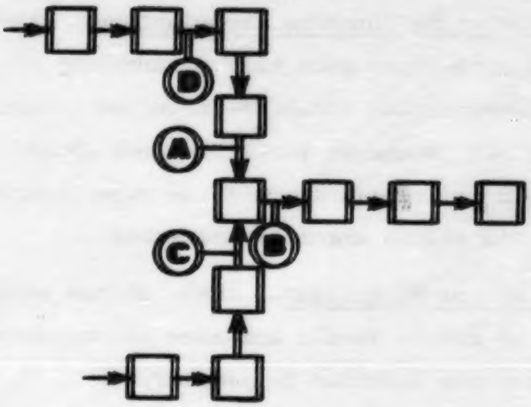
"1. Check that meter reads 75 ohms or less.
If not, go to______.

2. Check that meter reads 50 ohms or more.
If not, go to______."

A correct reading in each of the two steps would be between 50 and 75 ohms. A reading that failed the first step would be out of tolerance in the high direction, and a reading that passed Step 1 but failed Step 2 would be out of tolerance in the low direction.

4.5.3 Development of Action Trees. Action Trees shall be developed through use of the half-split strategy, as defined in 4.5.3.1, but modified in accordance with 4.5.3.2.

4.5.3.1 Half-Split Strategy. The pure half-split strategy dictates that each test be chosen so that the probability that the malfunction lies upstream of the test point (in the data flow) equals the probability that it is downstream. For the component block diagram shown below:



Assuming that all components have equal failure probability and are equally accessible, the first test location would be at point Ⓐ since the choice permits dividing the components most nearly in half. No other test point permits better than an 8-3 split. If a "good" indication is found at Ⓐ, the second test should be at Ⓑ or Ⓒ. If a "bad" indication is found at Ⓐ, the second test should be at Ⓓ. Each check eliminates about half of the components from consideration. These components are known to be "good." The choice of test location between the suspect components should be such that the check be made at the mid-point of the chain, and each succeeding check be made at the mid-point of the remaining portion of the chain. Thus, assuming each component has an equal probability of failure, the branching proceeds by halving the probabilities that the malfunctioning component lies on one side or the other of the check. This strategy defines the half-split technique of troubleshooting.

4.5.3.2 Criteria for Action Tree Development. Action Trees shall be developed by modifying the half-split strategy to maximize information gain per unit cost through the application of the following considerations:

a. Reliability. Checks for items with high failure rates should precede checks for items with lower failure rates.

b. Accessibility. Checks that are "quick and easy" should precede checks that involve extensive or time-consuming disassembly.

c. Probability of Malfunction Introduction. Those checks which involve activities with high probability of accidental malfunction introduction should be deferred toward the end of the procedure. Whenever a static check (power off) and a dynamic check can reveal roughly the same diagnostic information, the static check is preferred.

d. Location of the Technician. Other things being equal, the sequence of checks should minimize the movement of the technician from one location to another.

e. Test Equipment Setup. An unusually time-consuming test equipment setup should be weighed against information gained from the use of the equipment to consider whether its use should be presented earlier or later in the check sequence.

4.5.4 Tolerances. Tolerances, in the form of ranges of acceptable values within test/decision steps, shall be as follows:

a. The range of values for electrical continuity checks shall be "1 ohm or less."

b. The range of values for electrical insulation resistance checks shall be "50K ohms or more."

c. Manufacturers' ratings and tolerances for voltage and current shall be used to derive the range of values for power supplies.

d. Checks of individual components independent of their data flow context shall use manufacturers' ratings and tolerances (e.g., pump output, resistor value).

e. For operating parameters of the assembly under test, the tolerance range shall be determined empirically at each point of test. The empirical determination of these values shall be accomplished during validation, in accordance with 6.3.

4.5.5 Writing Requirements. Checkout Procedures and Action Trees prepared in accordance with 4.4 and 4.5 shall meet the writing requirements of 5.4. In addition, these tasks shall meet the following requirements:

a. When a Checkout Procedure and its associated Action Trees are combined into a single section, steps shall be numbered sequentially from the beginning of a Checkout to the end of the last Action Tree.

b. The last step in the Straight-Line-Checkout part of the Checkout Procedure shall be followed by the words "CHECKOUT ENDS HERE."

c. As with Job Guides, a step requiring no decision shall simply be followed by the next step.

d. When a step involves a test and its resulting decision, the next step shall follow from the affirmative outcome, and a branching instruction, e.g., "if not, go to step ___," shall follow from the negative outcome.

4.6 Illustrations. Illustrations shall be developed for every hardware item referred to in each Checkout Procedure and Action Tree. Locator illustrations and exploded views shall also be developed, as required. Illustrations shall be prepared in accordance with 5.5.

4.6.1 Duplication of Illustrations. Illustration requirements for Job Guides and Trouble-shooting Aids shall be coordinated to prevent the generation of duplicate illustrations.

4.7 Formatting Checkout Procedures and Action Trees. The formatting of checkout procedures shall be in accordance with 3.7.

5. GENERAL REQUIREMENTS

5.1 Organization by Sections and Volumes

5.1.1 Sections. Job Guides and Troubleshooting Aids shall be organized into sections according to the following subparagraphs. Each section shall contain one or more activities as defined in 3.4.1. Sections shall be numbered consecutively within the manual and pages shall be numbered consecutively within sections (e.g., the first activity of the second section will begin with page 2-1; the second activity could begin on page 2-10, etc.). The names of the sections and their content shall be as specified below.

5.1.1.1 Installation. The installation section shall contain all system-level tasks, i.e., tasks performed on the instrument as a whole, pertaining to unpacking and preparing the instrument for use. Such shall include tasks covering installation and attachment of the instrument to:

a. Sampling probes

b. Span and zero gas delivery systems

c. Chart recorders

d. Exhaust disposal plumbing

e. Remote readout and control systems

5.1.1.2 Calibration. This section shall include all activities relating to system-level calibrate tasks, including:

a. Calibration against a secondary standard

b. Zero and span calibration

c. Checks of the secondary standard

The primary calibration procedure i.e., calibration using the EPA reference method, will require chemical analysis skills not included in the user technician profile (see 1.5) and would not normally be included in the calibration section (but see 5.7.2). The user technician can be assumed to be able to use prepared reagents, set up simple sampling trains, and perform measurements using a spectrophotometer and so could perform an abbreviated and simplified version of the reference method as a check of the secondary standard. One example of this application would be to periodically check the output of the external ozone generator used as a calibration ozone source for an Ozone Monitor. Such could be performed by the user technician using a simplified version of the neutral buffered potassium iodide reference method. Out-of-tolerance results would indicate the need for primary calibration of the Generator.

5.1.1.3 Operation. All tasks relating to the operation of the instrument in any mode shall be included in the Operation section. Such tasks include:

a. Start-up
b. Normal manual operation (all normal modes)
c. Shutdown (normal and emergency)
d. Preparation for remote or automatic operation

5.1.1.4 Preventive Maintenance. Included in this section shall be all activities pertaining to the following maintenance functions:

a. Clean
b. Inspect
c. Lubricate
d. Service

5.1.1.5 Troubleshooting. This section shall include all Checkout Procedures and Action Trees developed in accordance with section 4.

5.1.1.6 Corrective Maintenance. All activities involving the following maintenance functions shall be included in the corrective maintenance section:

a. Adjust
b. Align
c. Calibrate
d. Disassemble/Assemble
e. Operate
f. Remove/Install
g. Repair

5.1.1.7 Supporting Data. This division shall consist of the Maintenance Support information developed in accordance with 5.7.

5.1.2 Order Tasks Within Activities/Activities Within Sections. Within a given activity, tasks shall be arranged in the order of the normal sequence of events in which they are performed (e.g., remove/install, disassemble/assemble, repair, align). If the tasks may be performed in more than one order, such variations shall be fully described in the activity Introduction. Where several alternative tasks may be performed in equally logical sequence, the most frequently performed tasks shall precede those performed less frequently. These same guides shall also apply to the ordering of activities within sections.

5.1.3 Ordering of Section. The order of appearance of the sections within the manual shall correspond to their order of presentation in subparagraphs 5.1.1.1 through 5.1.1.7.

5.1.4 Title Page. The first page in each section shall be a title page. It shall contain the name of the section, names of each activity within the section, and the page number on which each activity begins. See Figure 12 for an example of a section title page. One of two means shall be employed to facilitate location of the desired section by the user:

a. The section title page shall be made of a contrasting color, or

b. The section title page shall be tabbed with the section title printed on the tab.

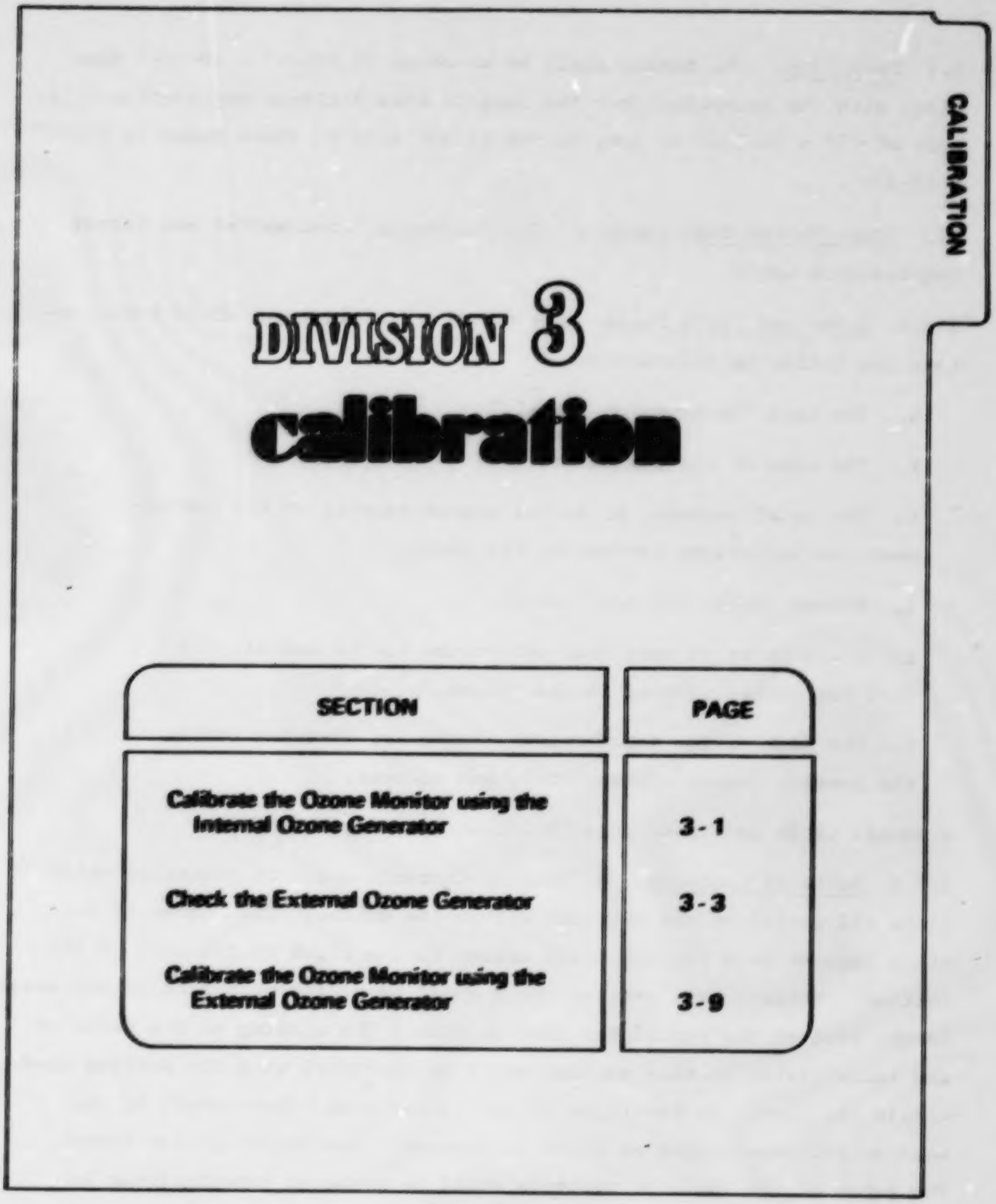
5.1.5 Volumes. Should the total page count for all sections exceed 300, the manual content shall be divided into two or more volumes, according to the following guidelines:

a. Each volume should have between 100 and 300 pages.

b. Sections should remain intact, i.e., no section should be continued into another volume.

c. Troubleshooting and Corrective Maintenance sections should be included within the same volume.

d. The ordering of sections as specified in 5.1.3 should not be altered.



CALIBRATION

DIVISION 3

calibration

SECTION	PAGE
Calibrate the Ozone Monitor using the Internal Ozone Generator	3-1
Check the External Ozone Generator	3-3
Calibrate the Ozone Monitor using the External Ozone Generator	3-9

Figure 12. Example of a Section Title Page

5.2 Page Size. The manual shall be produced in 8-1/4" x 10-3/4" page size, with the exception that the Support Data division may contain foldouts of 15" x 10-3/4" so long as the folded size of these pages is 8-1/4" x 10-3/4".

5.3 Front Matter Requirements. The following front matter and format requirements apply.

5.3.1 Cover and Title Pages. The cover and title pages shall both contain the following information:

a. The term "Instruction Manual."

b. The name of the instrument.

c. The model numbers, or serial number ranges, of the instrument configurations covered by the manual.

d. Volume number (if applicable).

e. Where there is more than one volume to the manual, the division titles covered in the volume.

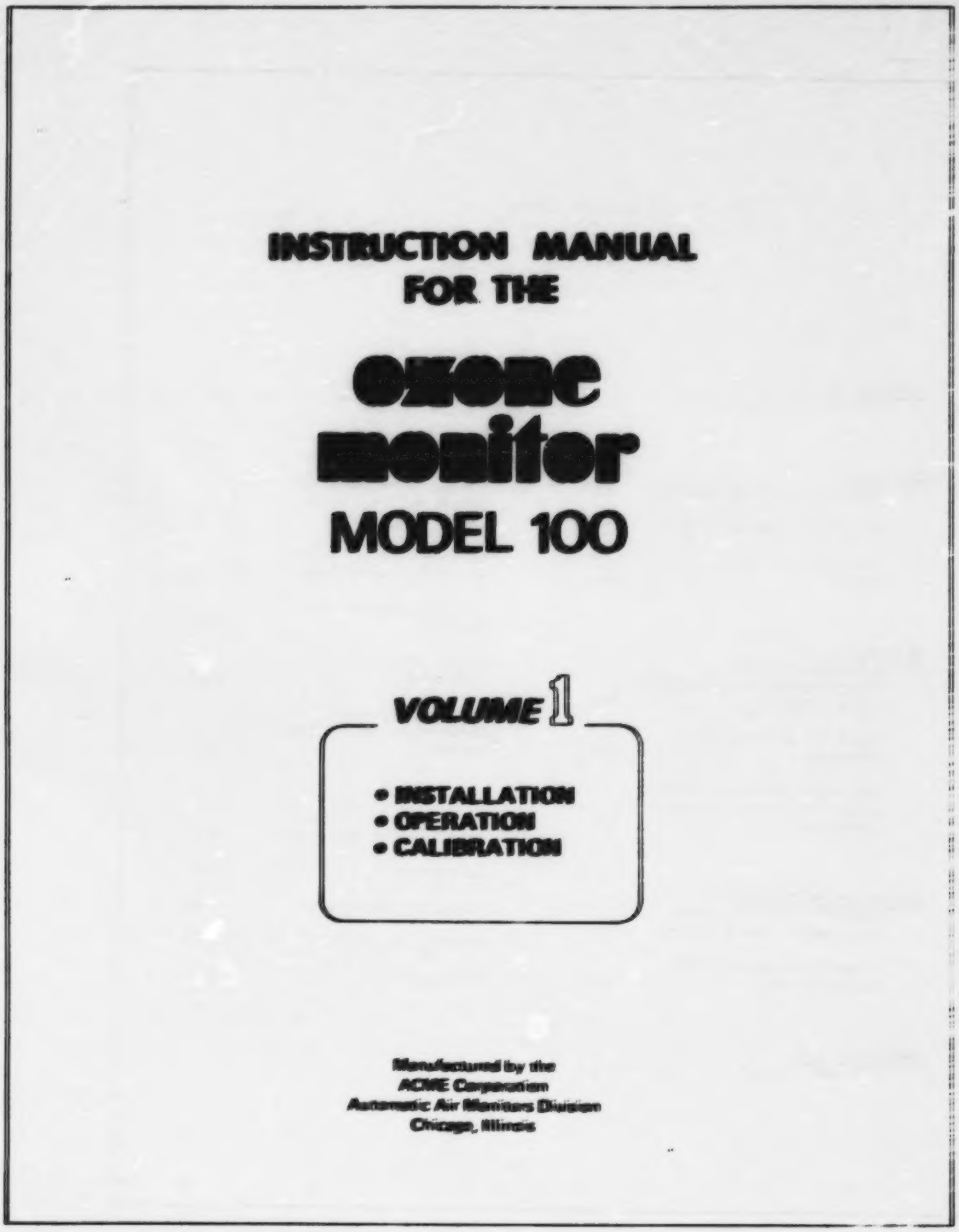
f. The name of the manufacturer, including division within the company (where appropriate), and address.

A sample title and cover page is included as Figure 13.

5.3.2 Table of Contents. A Table of Contents shall be presented which lists all divisions and sections within the volume. The number of the start page of each section shall appear to the right of the name of the section. Beneath each section there shall be a list of all tasks addressed in the text of the manual for that section. The wording of the names of the tasks listed in this section shall be identical with the wording used within the text. To the right of the listed task, there shall be the section and page number on which it appears. See Figure 14 for format. The pages of the Table of Contents shall be numbered consecutively in lower-case Roman numerals, beginning with i.

5.4 Writing Requirements

5.4.1 Mood. The second person imperative shall be used for maintenance instructions. The second person imperative mood is common language, telling



INSTRUCTION MANUAL
FOR THE

**ozone
monitor**

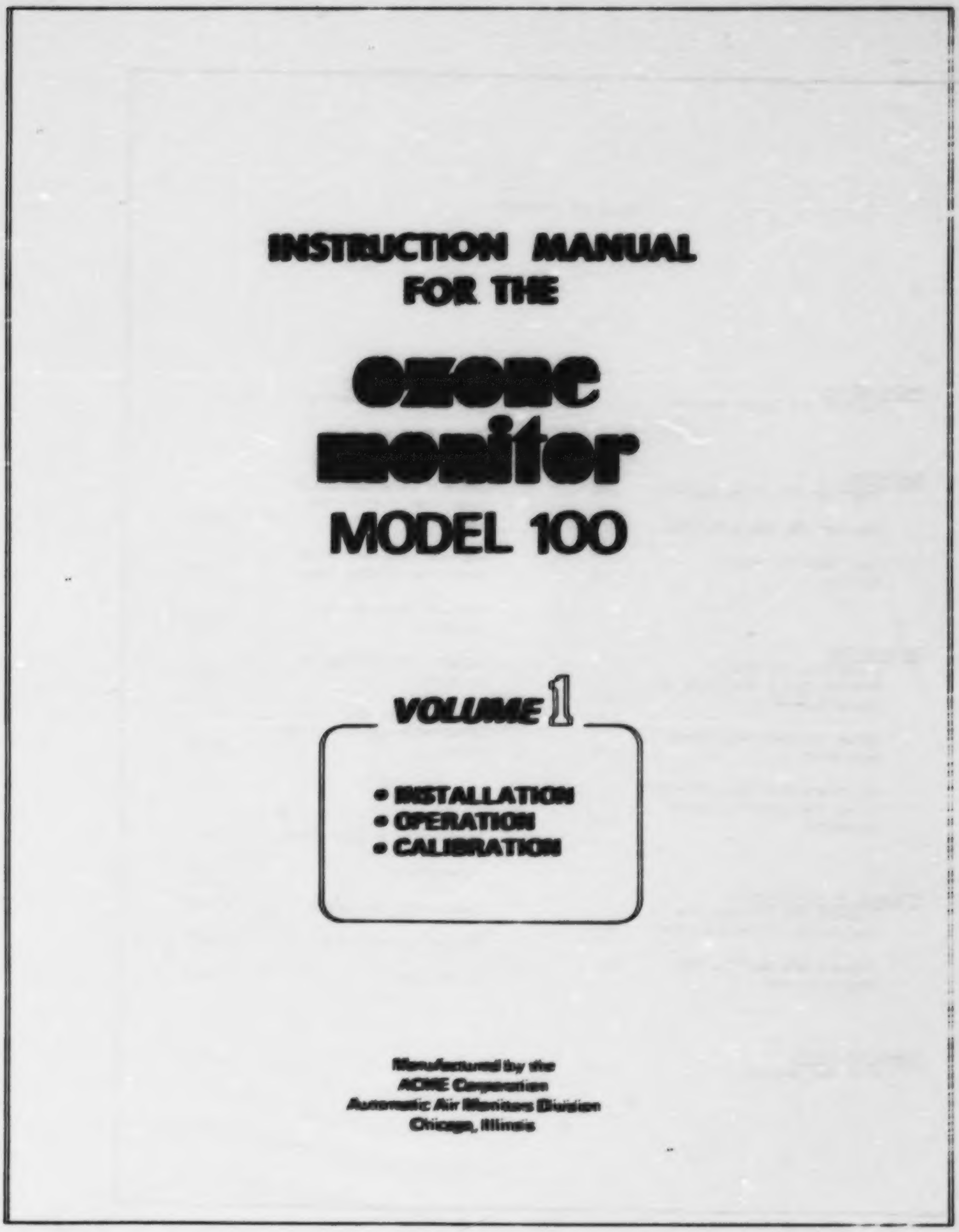
MODEL 100

VOLUME 1

- INSTALLATION
- OPERATION
- CALIBRATION

Manufactured by the
ACME Corporation
Automatic Air Monitors Division
Chicago, Illinois

Figure 13. Example Cover and Title Page



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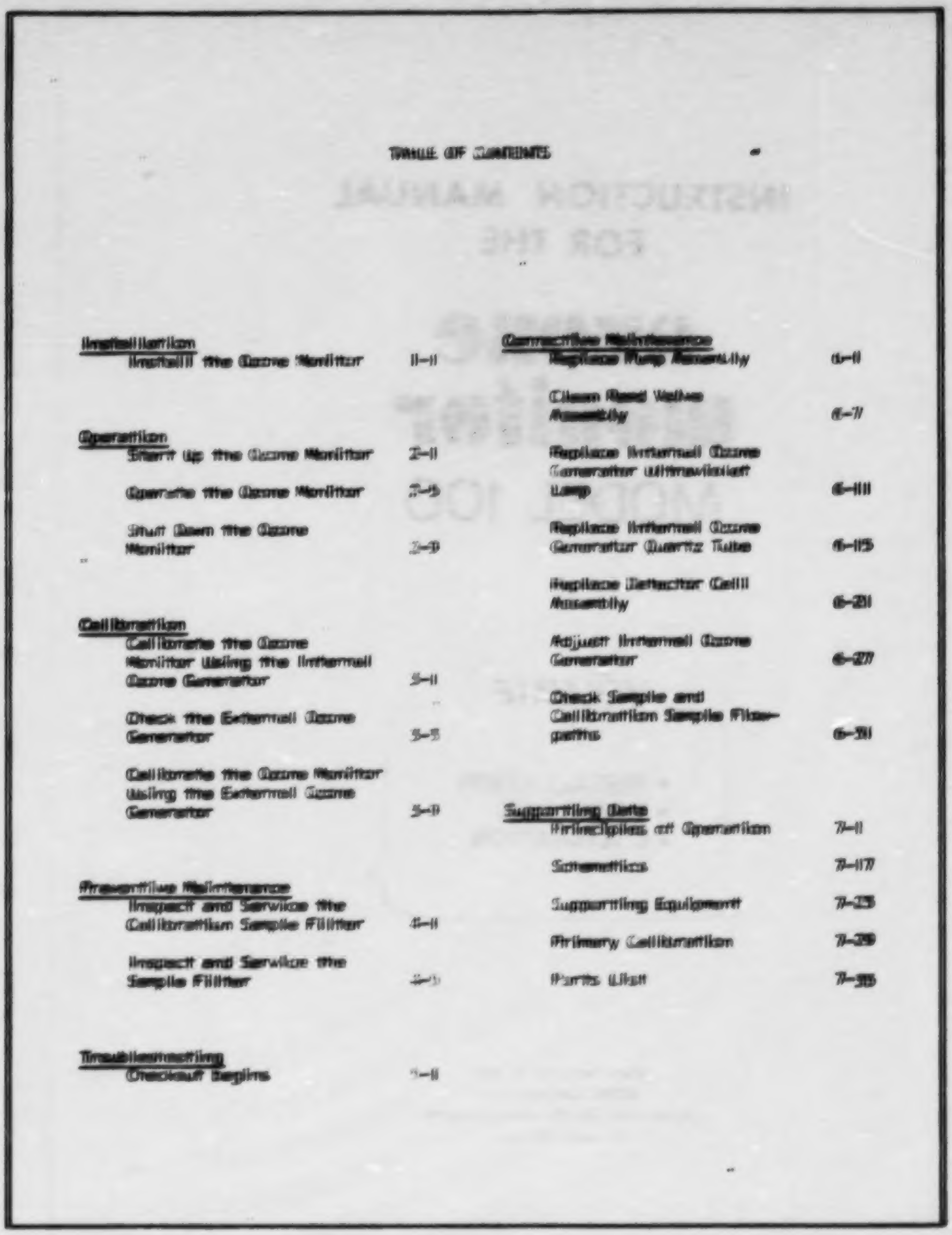

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Figure 14. Example of Format for Table of Contents

the technician what to do, e.g., set POWER switch to ON. The third person indicative mood shall be used primarily in Notes, Cautions, and Warnings, and for description and discussion statements. For example, "The diverter valve diverts ethylene flow to the bubblemeter." Articles shall be excluded for brevity.

5.4.2 Sentence Structure. The elements of a sentence should be arranged generally in the following order:

a. Subject. Implicit only, except when more than one technician is required.

b. Verb. Select from verb list that word (or phrase) which best describes the technician's behavior with respect to the object.

c. Object. The specific equipment to which the technician's behavior is directed.

d. Predicate Object. The term (or terms) which qualify the condition of the object (may not always be necessary).

e. Indirect Object. The location of the object (not preferred over pictorials to give such information).

For example:

(You)	Attach	tag	to control panel.	
(Implied Subject)	(Verb)	(Object)	(Predicate Object)	
Man A	sets	SELECTOR switch	to AMBIENT position	on front panel.
(Subject)	(Verb)	(Object)	(Predicate Object)	(Indirect Object)

When a special tool is called out as part of a step, the step statement shall be preceded by the word "using," and the tool name. For example, "Using snap-ring pliers, pull bushing from pump."

5.4.3 Verb List. Verbs used in any instruction shall be selected from the standard verb list in 7.3. This list may be modified to include new verbs as a clear and definite need arises. All changes to the list should be documented for review and approval by the procuring agency (see 6.2.3).

5.4.4 Generic Noun/Object List. A noun/object list shall be developed by the contractor and shall contain generic nouns for each class or type of object listed in the TIM. The list format shall contain the generic noun, examples from the TIM of the words the generic could replace, and its definition. Generic nouns are those which relate to a group or class of items rather than a specific item. For example, the generic noun "fastener" might be used in place of the specific names of a variety of fasteners (screws, bolts, clips, pins, etc.) where such would not result in ambiguity. The generic nouns in the noun/object list shall be used to facilitate the production of less encumbered and more readable task steps.

5.4.5 Official Nomenclature. The TIM shall be the official source of nomenclature for hardware items. Where the replacement of an item is necessary, the item shall be identified by its TIM nomenclature.

5.4.6 Colloquial Nomenclature. Within a maintenance instruction, a hardware item may be identified by nomenclature that is shortened or modified to reflect its relationship to the maintenance context. The nomenclature to describe a hardware item within a task shall consist of a generic noun characterizing the item and at least one preceding modifier of one of the following types:

a. Function. The name of the operation which the component or group of components performs in the unit (e.g., adjustment screw).

b. Type. A vital distinguishing physical characteristic (e.g., insulated washer).

c. Location. The differentiation of two similar parts on the basis of system location (e.g., motor bushing vs. pump bushing).

5.4.7 Nomenclature Guidelines. The following shall serve as guidelines for the use of generic, official, and colloquial nomenclature within the manual.

a. Consistency shall be maintained between the first and subsequent occurrences of each item of nomenclature in an instruction frame.

b. The detail of the nomenclature need not extend to the system level. For example, in a task involving work on a particular flowmeter, it would not be necessary to say "The Ozone generator sample plus ethylene flowmeter." It would probably be sufficient to refer to "flowmeter."

c. When an instruction is given to replace an item, the item shall be identified by both its TIM nomenclature and its illustration frame reference designator.

d. When an instruction is given to operate an item, it shall be identified by its generic noun unless the item is placarded, in which case the combination of the generic noun and the exact placarded display title shall be used. However, when a maintenance instruction places the technician in such a physical position that he is unable to see the placarded display title (e.g., when the technician is working on the wiring side of a panel), the item shall be called by the combination of its generic noun and its reference designator. The use of both the reference designator and the display title in this case is prohibited; the additional information is irrelevant to the task, and will only confuse the user.

e. Only information that is necessary to identify the item shall be included in the nomenclature.

f. Nomenclature appearing on the equipment in decals, engraved legends, nameplates, or other markings shall be stated in the text exactly as it appears on the hardware.

5.4.8 Standard Statements. Standardized sentences for stating task steps shall be used where task steps are very similar, such as repetitious steps and test equipment instructions. For example, the sentence stating instructions for use of a particular piece of test equipment may be the same except for expected reading, point of test, and "where-to-go-next" reference. Each occurrence of a similar event will be written using the same sentence, except for the unique variable(s) in the sentence.

5.4.9 Capitalization. The following words and items shall be capitalized: NOTE, CAUTION, WARNING, PRELIMINARY INFORMATION, SPECIAL INSTRUCTIONS, END OF SPECIAL INSTRUCTIONS, END OF ACTIVITY. Activity titles, component names, and control and display titles as engraved on the equipment shall also be capitalized. Equipment names shall not be capitalized unless they are so engraved.

5.4.10 Numbers. Numbers used in text shall be written out if one digit; if two or more digits, they shall be written as numerals (exceptions are test equipment readings and callout numbers). Equipment markings should always be written as engraved on the equipment.

5.4.11 Tolerances. When tolerances are required, the tolerances shall be written as a range of values (e.g., "adjust pressure gauge to 39-41 psi"). Measurements shall be written in the language of the tool used. For example, thousandths of an inch are appropriate if the technician is to use a feeler gauge.

5.4.12 Switch Setting Instructions. The following conventions shall be adopted for writing instructions with switches. For switches which hold their position once they are set, write: "Set (name of switch) switch to (position)." For setting several switches, begin at the top left and proceed clockwise - at a maximum of four switches per step. For springloaded switches which do not hold their position, write: (a) for a momentary setting: "Momentarily hold (name of switch) switch to (position)"; (b) for a longer action when a specific setting is required: "Place (name of switch) switch to (position) and hold until (result)."

5.4.13 Follow-On Maintenance. If, upon the completion of a maintenance activity, further maintenance is required to return the equipment to operational readiness, it shall be termed "follow-on maintenance" and treated in the following manner:

a. The "Maintenance in Progress" tag or other warning device shall not be removed from its location.

b. A note in the form of the following example shall be provided, including page reference to the subsequent task.

NOTE

Follow-On Maintenance Action Required:
"Calibrate the Ozone Monitor" (p. 60)

5.4.14 Method for Cross-Referencing. When referring to material contained elsewhere in the Job Guides, the writer shall provide the reader with sufficient information to proceed directly to the referenced material. For example, Install Sample Pump, refer to p. 156.

5.4.15 Composition of Maintenance Steps. Each step shall contain no more than four sentences, and no more than 35 words. Any one sentence shall contain no more than 15 words. Where possible, each step shall contain one or more references to the accompanying illustration.

5.4.16 Method for Keying Text to Illustrations. Each time a part or location is mentioned in the text, it shall be followed, in parentheses, by a locator number (callout) from the accompanying illustration.

5.4.17 Safety Requirements. The text shall contain Warnings, Cautions, and Notes on the page(s) where applicable. Warnings and Cautions shall state specifically: (1) the hazard, (2) the likely result if the hazard is ignored, and (3) specific steps to take to avoid the hazard.

5.4.18 Assistants. Steps for an assistant shall all be written exactly as those for the primary technician, except they shall be introduced by the phrase, "request that assistant . . ." They shall be incorporated in procedures in places appropriate for proper coordination and smooth flow. Locator information shall be provided as necessary for assistants.

5.4.19 Multi-Man Activities. When two or more technicians must perform more than three steps, procedures shall be prepared separately for each man, and a requirement stated on the Preliminary Information Page for each man to be in possession of a copy of the procedure during task performance. Each procedure shall include all steps required of the individual during the activity. All steps shall be written as for a solitary technician. Only those steps actually performed by the individual technician shall appear in his respective activity procedures. Man A's steps shall not be presented to Man B and vice versa, except in those cases needed to clarify coordination and communication.

In such cases, the communication instruction shall pick up both men at that point in the activity where they must cooperate. For example:

Situation 1 - when one man's step is not to be started until the second man completes a given step. A note shall be provided to the first man advising him not to start until a report is received from the second man. The second man shall be instructed to report when he completes the given step, and the instructions shall be incorporated in the step. A description of the nature of the report shall be specified for each report and each response, e.g., "report when ready to observe pointer"; "do not start until Man A reports he is ready to observe pointer."

Situation 2 - when one man performs a given step and the second man checks the equipment response to the step. A note shall be provided to the first man not to start until the second man reports he is ready. A one sentence description of the equipment action controlled by the step shall be included. A note shall be provided to the second man indicating that the step is in response to an action by the first man and to report when ready. Instructions shall be provided telling when to report.

Situation 3 - when the cooperative step may require repetition and instructions to repeat the step cannot be condensed. A short description of the anticipated equipment response shall be provided in a note preceding the step to the man checking the equipment response. If subsequent cooperative actions are different from those in the completed action, they shall be treated the same as Situations 1 and 2.

5.4.20 Special Instructions. A special instruction may occur when a task is repeated within a volume. To prevent the necessity for presenting the same task several times in the same volume, it may be designated (on the first occurrence) a "special instruction" and referenced when required. Before the special instructions may be referenced, the following conditions shall be met:

a. Two or more steps are repeated in sequence.

b. If reference information is used, the same reference applies to each repeat.

c. The steps are identical except they are applicable to a different control or display.

The special instruction shall be uniquely titled. It shall be explicitly labeled "SPECIAL INSTRUCTION" and the end of the special instruction shall be denoted by the phrase "END OF SPECIAL INSTRUCTION."

The special instructions shall be referenced by: "perform (special instruction title), (page number)," i.e., "perform Leak Detection Test, (p. 4)."

5.4.21 Activity Endings. The phrase "END OF ACTIVITY" shall appear at the end of each activity, also for each man's pages within a combined package.

5.4.22 General Safety Provision. An activity ending shall not leave any portion of the equipment in an inoperable or dangerous condition without adequate warnings being provided for all individuals likely to be affected.

5.5 Illustration Requirements. Only line artwork shall be prepared. Line artwork shall be prepared such that ozalid or equivalent copies of the original artwork may be obtained.

5.5.1 File of Original Art. A complete file of reproducible copies of original artwork used in the illustration frames shall be maintained and updated by the vendor during the manual production process. Each illustration (locator, detail view, exploded view) shall be uniquely identified by a number according to which the illustration is filed.

5.5.2 Identification of Illustrations. Each time an illustration appears on a frame, the illustration shall be accompanied by its file number, which shall appear below, to the right of, and immediately adjacent to the illustration. The number shall be placed so as to be readily discriminable from and readily identifiable with the illustration itself, and the numerals shall be no larger than 6-point nor smaller than 4-point in final reproduction size.

5.5.3 Quality of Illustrations. Line weights shall be of sufficient density to reproduce sharply and clearly at the final reproduction size. Illustrations shall have no unintentionally broken lines, faded areas, or blotches in place of details (e.g., when improperly drawn and reproduced, screw threads appear as dark areas). Any feature referred to by the text (e.g., screw head, contact, hold) shall be at least as large as the smallest type used in the text of the manual. No shading, stippling, or scratching shall be used, with the exception of line shading and zipatone. Thick weight lines shall be used for shadow and rear lines while thin weight lines shall be used for light areas and front lines. Thick lines may be used to outline the critical components of complex illustrations. Object lines shall be broken 1/64 - 1/16 inch where that object is partially obscured by another and on each side of a callout where it crosses that object (see Figure 15). Nonlines shall be used for lines of reflection (see Figure 15). Jagged lines shall be used for cut-away views, while dashed lines shall be used only for hidden objects. Standard center lines shall be used for axes of assembly.

5.5.4 Level of Detail. The illustrations in a frame shall present only the equipment to which the actions in the frame refer, plus sufficient surroundings to permit swift localization of the pertinent equipment item or part. Detail that serves only to conceal the hardware item discussed or to confuse the user of the manual must not be used, but enough information shall be included to allow the technician to locate and isolate the hardware item without error (e.g., in locating a particular gauge on a large panel, the markings of each gauge need not be included, but the outline of every component on the panel shall be included). If all illustrations required to support a frame of text will not fit in a single frame, the text shall be put in two or more frames, each with its supporting illustrations.

5.5.5 Angle of View. Illustrations shall be drawn only from the angle of view of the technician during a given step of the procedure. Cut-aways and hidden lines shall be used only in conjunction with text references to details that are accessible but not visible to the technician; and these views also shall be drawn from the technician's orientation. Illustrations from any other point of view will only confuse and disorient the manual user. In situations where the technician may view the hardware from more than one angle, the view which provides the most pertinent and necessary information in the most simple fashion shall be used (e.g., orthographic flat, trimetric). An item or part removed from the system may be rotated to show important features, but the axis, direction, and degrees of rotation shall be indicated in the illustration.

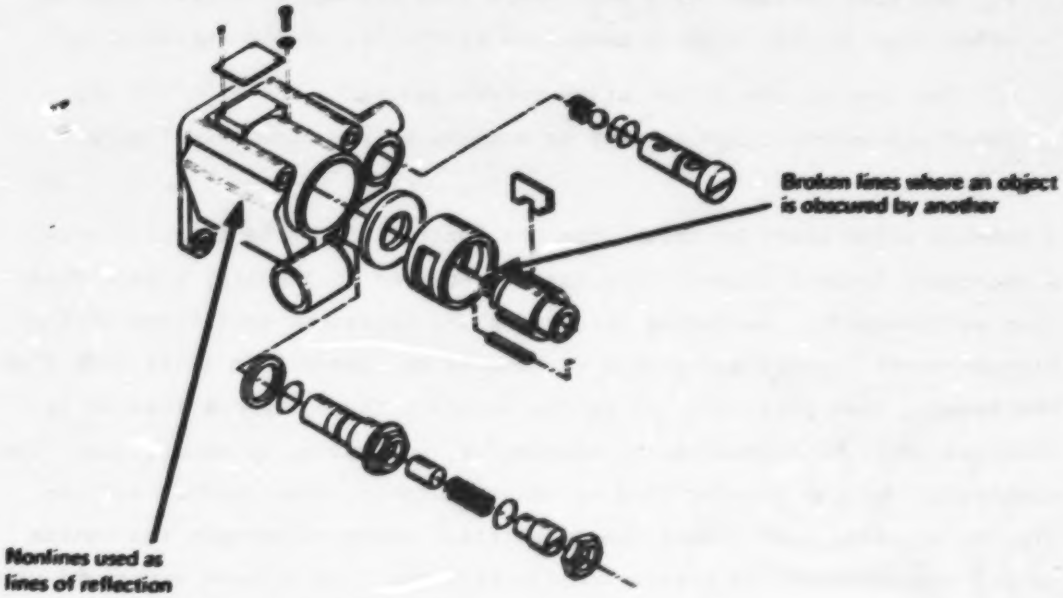
Broken lines where an object is obscured by another
Nonlines used as lines of reflection

Figure 15. Exploded View

5.5.6 Locator Illustrations. When an equipment item is first illustrated in an activity and its location has not yet been specified by previous procedures or illustrations, a locator illustration shall be used to identify the equipment item and its location on the instrument. The specific item shall be represented in the locator illustration in one of the following fashions:

a. The item shaded black (solid or crosshatched), with the outline shaped to correspond to that item (see Figure 16, upper illustration).

b. The item outlined by a continuous line heavier in weight than any other line in that illustration (see Figure 16, middle illustration).

c. The area of the illustration corresponding to the item and its immediate surroundings circled by a heavy weight line (see Figure 17).

A locator arrow shall be drawn from the locator to a more detailed view. A secondary locator illustration may be required to identify a particular item sufficiently. Secondary locators shall represent satellites of the highest-level locator and should be located no closer than 1-1/4 inch from the locator when possible. As in the locator, the equipment item to be enlarged shall be identified by blackening, outlining, or encircling. The combination of the locator (and secondary locator, when needed) and the item enlargement must enable the technician, starting outside the system under consideration, to locate and identify the item without error and without aid from the text (see Figure 16).

5.5.7 Item Enlargement. Enlargements of hardware items shall represent satellites of the locators. Item enlargements, when arranged around a specific locator, should be spaced no closer than 3/8 inch from each other and from the locator when possible (see Figure 16, bottom illustration).

5.5.8 Exploded View. An exploded view may be required to illustrate assembly, disassembly, removal, and installation of parts. Exploded parts shall be shown aligned on a standard center line to indicate their actual location in the assembly. Object lines shall be broken 1/64 - 1/16 inch where that object is partially concealed by another. All parts included in an exploded view shall be drawn to equal scale. Callout lines should

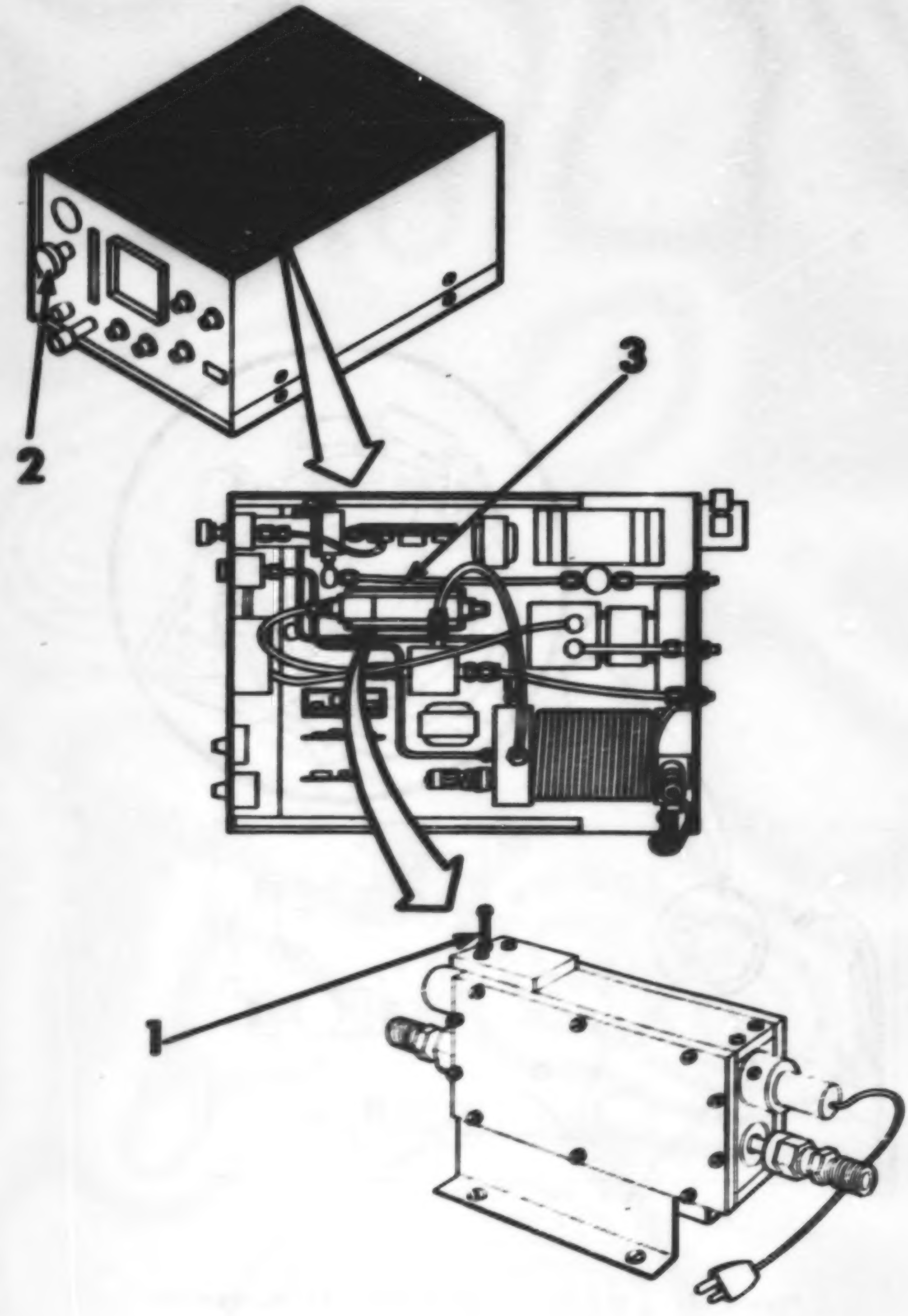

Figure 16. Primary and Secondary Locator Illustration with Item Enlargement

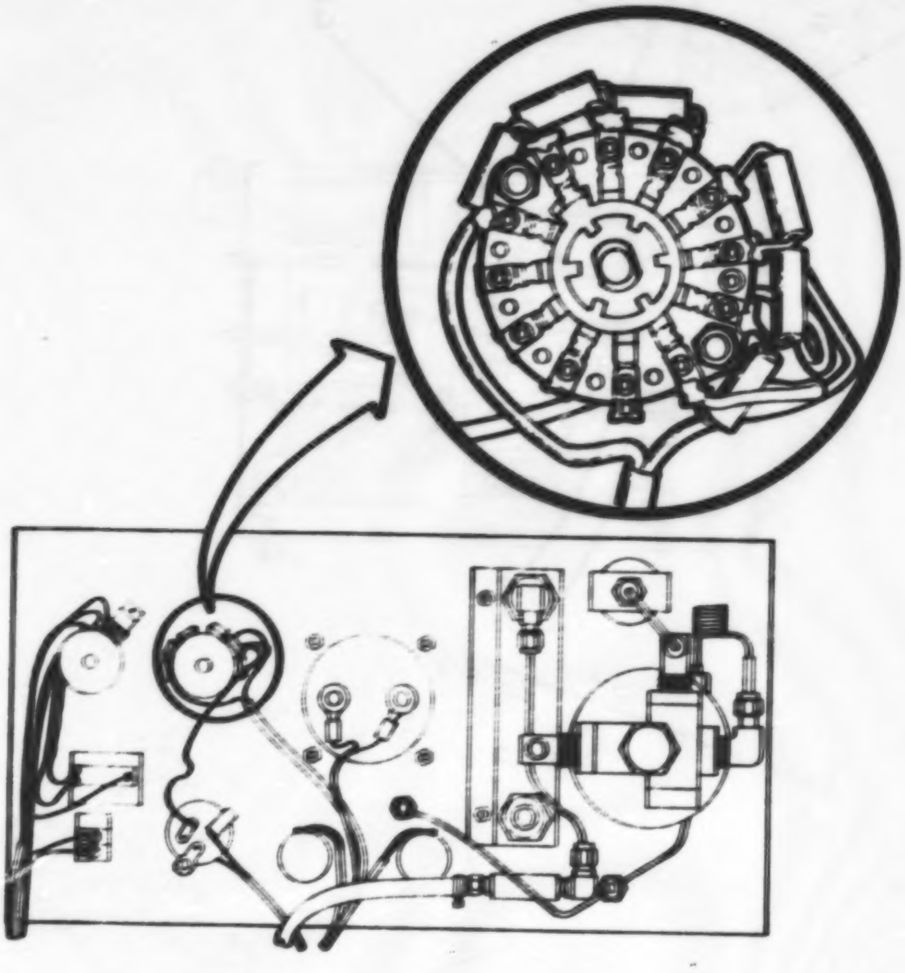

Figure 17. Circular Locator View and Enlargement

not be drawn parallel or perpendicular to object outlines or to breakdown axes whenever possible. Callout numbers shall not be crowded into spaces between parts. No arrows shall be used to connect the exploded view to other illustrations on the same page. Parts shall be spaced far enough apart to ensure their identification (see Figure 15).

5.5.9 Interconnecting Arrow Symbology. Arrows leading away from a locator to secondary locators and away from a locator to enlarged views shall be unnumbered, tapered, with solid white body such as the Copyaid S5398W or its equivalent, and shall point to the secondary locator or item enlargement. The base of the arrow shall precisely touch the outer edge of the area being located. The enlarged view should be located within 1/2 inch of the locating arrowhead. Figure 16 illustrates the proper style and use of arrows with the locator illustration. Object lines shall be broken 1/64 - 1/16 inch on each side of the interconnecting arrow.

5.5.10 Callouts. Specific features of interest shall be pointed out on the item enlargements and the exploded views with callout lines. An arrow shall connect the callout number to the correct feature of interest on the illustration. Callouts shall be limited to only those used in the instructions on the two pages of the frame. The arrows and heads shall be Paratone type 44001 or a directly interchangeable equivalent and shall point precisely to the outline of the feature of interest, concealing as little of the illustration as possible. Callout arrows should not be drawn parallel or perpendicular to object outlines or breakdown axes whenever possible. Figure lines shall be broken 1/64 - 1/16 inch wherever callout arrows cross those lines.

5.5.11 Numbering of Callouts. The callouts within the illustration area shall be consecutively numbered. Callout numbers shall begin on the drawing at approximately the three o'clock point and proceed clockwise around the first functional segment enlargement and clockwise from item to item around the page. For frames where there is illustration area on both pages of frame, the left-hand page will be assigned callouts first, starting at the three o'clock position. Then callouts will continue in numerical order on the right-hand page starting again at the three o'clock position. Numbers should not be placed between parts or items whenever possible.

5.5.12 Orientation Direction Arrows. Arrows indicating the line of regard with respect to the system shall be included in illustrations where the orientation of the enlargement is different from the orientation of its locator (see Figure 18).

5.5.13 Special Tools, Test Equipment, and Materials. Special tools, test equipment, and materials shall be illustrated, where applicable, according to the specifications provided above.

5.6 Typography and Lettering. These shall be as stated in Table 1.

5.7 Maintenance Support Information.

5.7.1 Contents. The Maintenance Support Information may contain, but shall not be limited to, the following types of information:

a. General Instrument Information. This information shall include descriptions of the instrument, its purpose, principles of operation, dimensions, capabilities, main functions, and subsystems. Information shall be presented in the form of charts and tables where appropriate.

b. Performance Specifications. See 7.2 for the list and definitions of performance specifications to be included.

c. Schematics. Schematics covering each model or configuration included in the manual shall be included.

d. Primary Calibration Procedure. See 5.7.2.

e. Support Equipment Descriptions. See 5.7.3.

f. Replacement Parts Data. See 5.7.4.

g. Other Support Information whose format may not be compatible with the standard Job Guide presentation. See 5.7.5.

5.7.2 Primary Calibration Procedure. The EPA recommended reference method and primary calibration procedure applicable to the subject instrument at the time of manual publication shall be described as part of the maintenance support information. The following types of information shall be provided.

a. Description of the Primary Calibration Procedure. A short description of the primary calibration procedure shall be included along with

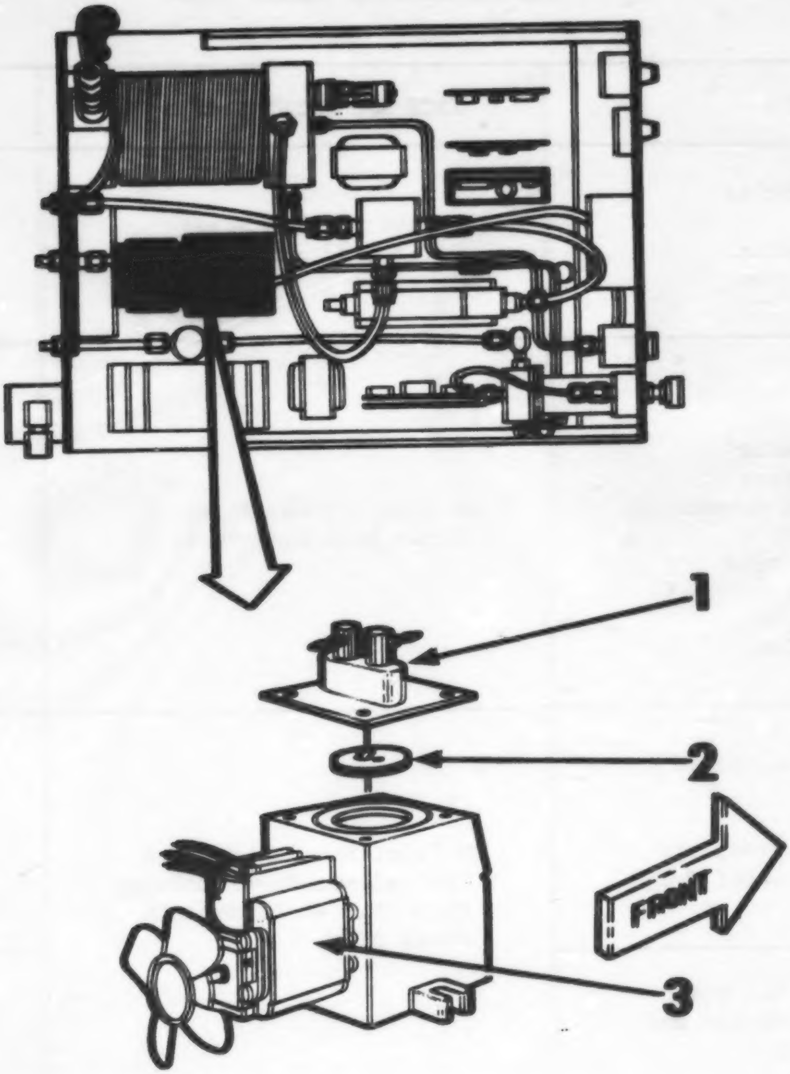

Figure 18. Proper Use of Orientation Arrows

Table 1

Typography and Lettering for Instruction Manual Pages

USE	FACE AND POINT SIZE	CASE
Figure Titles Illustration Orientation	12 Point (Final Size) Extra Bold Sans Serif	Upper
Callout Numbers Alphanumeric Designators (Blocked Schematic) Block Letters Designating Paragraphs (Keyed Text)	18 Point (Final Size) Extra Bold Sans Serif	Upper
Chapter and Section Titles Note, Caution, and Warning (Word Only)	10 Point Futura Light or Equivalent, Never Reduced More Than 40 Percent in Final Size	Upper
Body and All Other Written Matter and Lettering		Upper and Lower

references to detailed technical descriptions describing it (e.g., references might include the Federal Register, and EPA Environmental Monitoring quality assurance publications).

b. Description of Application to the Subject Instrument. Complete step-by-step guidance shall be provided to assist the technician in reconfiguring the subject instrument (e.g., changing the plumbing connections) as necessary to perform the primary calibration. Illustrations and all applicable Cautions, Warnings, and Notes shall be provided. At least one illustration shall show the total configuration ready for primary calibration, including all relevant support equipment (e.g., span gas delivery systems), the instrument itself, and the complete and correct sampling train.

5.7.3 Support Equipment Data. Descriptions of all types of support equipment used in operation and maintenance of the instrument shall be included in this section, together with illustrations and instructions for their use. These instructions shall include all applicable Notes, Cautions, and Warnings. Examples of support equipment include:

a. Span gases
b. Gas delivery regulators
c. Traps and filters
d. Hoses and tubing

Both vendor supplied and equipment to be supplied by the procuring agency shall be included. In the case of procuring agency supplied equipment, coverage should be of commonly available, acceptable quality, representative equipment item examples. Alternate suppliers and suppliers part numbers for each such equipment item should be provided.

5.7.4 Replacement Parts Data. A parts list which includes the name reference designator, model or configuration applicability, and vendor parts number shall be included. All information necessary to assure minimum delay in obtaining replacement parts shall be included along with all information necessary to facilitate:

a. In-the-field servicing by the vendor

b. Return of the instrument for factory repair

5.7.5 Other. Other types of information which may be included in the Maintenance Support Information are:

a. Lubricants, description and uses

b. Torque-tolerance data tables

c. Tables of measures and conversion equivalents

5.7.6 Format. The format for Maintenance Support Information shall be generally consistent with the formats specified in 3.7.

6. QUALITY AND ACCURACY ASSURANCE PROVISIONS

6.1 Procuring Agency Options Concerning Quality and Accuracy Assurance. The procuring agency shall have the option of specifying the approach whereby it can review and influence the form and/or content of intermediate products and/or the Instruction Manual. The procuring agency may elect one of two Options, depending upon whether the vendor can demonstrate the existence of an acceptable JPA-type Instruction Manual for the subject instrument.

6.1.1 Option 1 - Determination of Existing JPA-Type Manual Acceptability. Where the vendor presently has a potentially acceptable JPA-type Instruction Manual covering the identical model and configuration of the instrument which is the subject of the procurement, the vendor shall include this manual and supporting data as part of his bid/proposal package. The procuring agency shall review the manual and supporting data and determine the tentative acceptability of the manual.

6.1.1.1 Requirements for Potential Acceptability. In order for the existing JPA-type Instruction Manual to be considered potentially acceptable by the procuring agency, it must have been developed in accordance with this specification and subjected to the Option 2 quality and accuracy assurance evaluation, as set forth in 6.1.2, in at least one previous procurement.

6.1.1.2 Supporting Data Requirements. Supporting data to be submitted with the existing Instruction Manual shall include:

a. The TIM, annotated for Read/Book Tradeoff, including the Read/Book Tradeoff decision rationales.

b. An illustrated parts breakdown, listing all parts and part numbers.

c. A complete set of general locator illustrations.

d. An electrical schematic.

e. A complete process flow diagram showing and describing all instrument inputs, e.g., sample, power, span gas, etc.); all major functions in all instrument subsystems (e.g., power supply, sample path, calibration sample path, detector/reaction chamber, pumps, valves, etc.); and instrument outputs.

f. The Test Equipment and Tool Use Form.

g. The Function/Function Failure Analysis

h. The List of Malfunction Symptoms.

i. Names of companies or other agencies now employing the manual, including names of persons responsible for those procurements.

All supporting data items shall be for the identical model and configuration as the subject instrument.

6.1.1.3 Determination of Tentative Acceptability. The procuring agency shall, at its option, review all or parts of the manual and supporting data, according to 6.2, as necessary to assure that the existing manual is complete, accurate, and in compliance with this specification. Within 30 days of contract award the procuring agency shall provide the vendor, in writing, with:

a. Notification that the Instruction Manual is acceptable in its existing form.

b. Changes in the manual or interim products (see 6.1.1.2a, f, g, and h) which must be reflected in the manual to be supplied with the subject instrument.

6.1.2 Option 2 - No Pre-existing Manual. In cases where the vendor has not previously produced an Instruction Manual for the identical subject instrument, a manual will be first developed as part of the subject procurement. All interim products developed in accordance with 2.5, 3.2, 3.3, 3.7, 4.2, 4.3, and 4.7 shall be submitted to the procuring agency as they are developed, along with appropriate supporting documentation (as defined by 6.1.1.2b, c, d, and e). The review of these interim products shall be as specified in 6.2.

6.1.3 Verification. Regardless of the Option employed, the procuring agency may elect to verify the completed Instruction Manual. Verification is a process whereby a user technician attempts to perform all or selected

Job Guides or troubleshooting tasks in the manual under actual conditions, supported only by the manual. Based on this evaluation, the procuring agency may request, within 60 days of the delivery date, changes in text or illustration on a maximum of 15 percent of the total page count in the manual. Each such page shall be revised and reproduced in accordance with this specification and supplied to the procuring agency in a number equal to the number of Instruction Manuals delivered with the original procurement. No additional charge will be made by the vendor for such revision and reproduction.

6.2 Review of Products. Review of any or all products provided by the vendor in accordance with 6.1.1 or 6.1.2 shall be totally at the option of the procuring agency. The agency may elect to review a given product in its entirety, or to review selected parts of it. Exercise of this option, however, shall not excuse the vendor from providing all such products and supporting data, except with the prior approval of the procuring agency.

6.2.1 Review Criteria. The following criteria will be employed by the procuring agency in the review of products:

a. Consistency – is the product consistent with the support data?

b. Accuracy – does information accurately reflect the supporting data?

c. Completeness – does the product contain sufficient information to effectively serve its intended purpose?

d. Applicability – is the data relevant to the identical instrument being supplied?

e. Usability – is the amount of information and style of presentation appropriate to the user technician within the procuring agency?

f. Scope of Troubleshooting – will the checkout(s) and Action Trees uniquely isolate each MSP?

6.2.2 Time Limitations for Review. The allowable time period for product review by the procuring agency shall be determined during contract negotiations. Scheduling of review deadlines shall not jeopardize the proper performance of the validation activity (see 6.3).

6.3 Validation. Validation is the process by which the vendor tests the JPA intermediate products and final products for accuracy, adequacy, completeness, and appropriateness to the level of the technician who will use the manual. It also determines whether adequate notes, warnings, and cautions have been included where and when necessary to ensure against danger to the user and the equipment. Normally, it is also the phase of troubleshooting aid development during which tolerance data are empirically determined in accordance with 4.5.4, and appropriately recorded.

NOTE:

> Validation is not a prelude to verification but rather a complete process by which the vendor guarantees the technical integrity of his products. Significant omissions, errors, or misconceptions discovered during verification will indicate that the vendor did not properly perform the contract item requiring Validation Certification.

6.3.1 Scope of Validation. The Task Identification Matrix (TIM), Job Guides, Action Trees, and Checkout Procedures shall be validated in their entirety (100 percent validation) with all procedural tasks and troubleshooting logic checked by actual performance.

6.3.2 Place. Validation shall take place where the instrument is available on a full-time basis for operation, alignment, disassembly, inserting of troubles, and repair. Validation can take place either at the vendor's facility or at actual instrument sites operated by the procuring agency.

6.3.3 Validation Certificate. A Validation Certificate shall be provided by the vendor as a guaranty that the validation process was performed in accordance with 6.3. When completed and signed by the vendor's technical and management personnel responsible for validation, it certifies to the procuring agency that the preliminary Instruction Manual is accurate, complete, and compliant with all intents and procedures required by the contract in order to meet the intended use by the procuring agency. It shall further specify that the instrument as delivered is fully capable of performing in accordance with all performance specifications included in the contract.

6.3.4 Personnel. The personnel who participate at all validation proceedings shall include as a minimum:

a. Vendor technical authority (a technical expert such as an engineer) who can attest to the technical accuracy of procedures and their appropriateness to maintenance philosphy, test equipment, provisioning philosophy, etc.

b. Vendor quality assurance representative who is empowered to ensure that the validation is performed to the letter of contractual specification.

Full or part-time attendance is also recommended for the following:

a. Writing personnel who developed the Job Guides and Troubleshooting Aids.

b. A "subject" to perform procedures who possesses training and technical capability similar to the intended user technician.

c. Vendor management personnel.

6.3.5 Schedule. The vendor shall make certain that the formal validation process is scheduled well in advance of verification so that there is ample time for procedural revisions, corrections, and access to the equipment for revalidation if necessary. Validation of the Task Identification Matrix (TIM), Job Guides, Action Trees, and Checkout Procedures may require an ongoing validation which continues during much of the life of the contract. It may also be necessary to consider a team of "validators" that concurrently performs the validation at the equipment site so as to make certain that contract schedules are met.

6.3.6 Validating the Task Identification Matrix. The vendor shall perform validation of the entire Task Identification Matrix as one of the first JPA development tasks immediately following the TIM review (6.2). When the TIM in-process review is completed, the TIM shall be validated by the vendor in the following manner:

a. Select personnel who are technically qualified (design engineer, field maintenance instructor, etc.), have in-depth knowledge of maintenance performed on this instrument, and are technically capable to make decisions based on factors such as maintainability, spares levels, maintenance philosophy, and availability of test equipment.

b. Instruct validation personnel that each hardware item must be analyzed for its agreement with the task analyst's recommendations during TIM development (e.g., Can it be aligned? Can it be repaired?—and at what level?), as well as for its prescribed maintenance function and the facility with which that maintenance function can be performed (i.e., nothing obstructs technician access; the item is not encapsulated, etc.). The TIM should be corrected, if it is in error, by the validating team.

c. Make certain that any parts of the TIM that are found during validation to be missing or significantly wrong are revalidated, preferably by the same validation personnel.

6.3.7 Validating the Test Equipment and Tool Use Form. The vendor shall validate the Test Equipment and Tool Use Form (TETUF) concurrently with the validation of the Task Identification Matrix (TIM). The TETUF shall be validated and approved by the same personnel that validate the TIM (see 6.3.6.a). Validation of the TETUF shall show that it satisfies the following requirements:

a. It reflects the procuring agency's approved list of tools and test equipment.

b. The TIM maintenance functions can be performed with the specific items listed in the TETUF.

c. The standard statements involving special tools and test equipment to be included in the JPA are appropriate for the specified intended audience.

6.3.8 Validating the Job Guides. The vendor shall validate each and every procedural task step (100 percent) on the instrument as written in the Job Guides. The vendor's validation process shall ensure that all procedural steps are written and illustrated to the appropriate skill level of the intended user technician. Vendor personnel who perform such validation procedures shall use only the test equipment and tools in the approved and validated TETUF.

6.3.9 Validating the Checkout Procedures and Action Trees. The vendor shall perform validation of each Checkout Procedure and Action Tree, and shall comply with the following rules of validation:

a. Validation shall establish that every component failure mode found by an Action Tree produces, in the Checkout Procedure, the symptom for which the Action Tree was written, and that the Action Tree logic isolates the component. This validation shall be accomplished empirically by actual physical simulation of each component failure mode.

b. An Action Tree, or part of an Action Tree, need not be completely validated if it can be demonstrated that it is identical to an Action Tree or part thereof that has already been validated. In such a case failure modes shall be simulated only to the extent necessary to determine that the symptom produced is the one for which that Action Tree was written.

c. In the process of validating the logic of each Action Tree, the vendor shall also determine the tolerance range of all application-specific readings. These tolerance ranges shall be established by simulating the failure mode in such a way that the entire range of failure (e.g., range of flow rate or range of resistance values) can be observed and the points in the range can be noted at which the symptom appears.

d. Malfunctions that would tend to produce power supply overload shall not be simulated beyond the point at which they would produce the full rated load for the supply (as measured by a pressure gauge, ammeter, etc.)

e. Action Trees submitted for validation shall be accompanied by illustrations keyed to the procedural and decision steps, and reproduced in the intended final reproduction size. As the Action Tree branches are followed to validate the procedures, all illustrations shall be examined for adequacy of support for these respective steps.

6.4 Pre-Publication Review. If Option 1 (6.1.1) is employed, immediately after validation, the vendor shall incorporate comments, corrections, and improvements found to be necessary during validation. The vendor shall implement the changes and will make sure format and illustrations are corrected and quality checked.

The vendor shall prepare and deliver a pre-publication draft of the Instruction Manual for final review and approval by the procuring agency.

6.5 Errata and Change Sheets. The vendor shall, for a period of two years following the delivery date of the subject procurement, provide errata and change sheets covering all errors discovered and modifications found to be required in the Instruction Manual.

7. GENERAL DEFINITIONS AND VERB LIST

7.1 Definitions. The following definitions shall apply:

a. Action Tree. A branching troubleshooting procedure that isolates every possible cause of a malfunction symptom. An Action Tree is written for each unique malfunction symptom.

b. Activity. A single task or a group of tasks that are usually performed in the same sequence. Each section contains at least one activity.

c. Failure Mode. One of the ways in which a component can fail. Some components may have only a single failure mode, e.g., a lamp can be open. Other components may have more than one way of failing, each with different possibilities for production of symptoms, e.g., a solenoid can have an open coil, an insulation breakdown in the coil, or a mechanically-induced restriction in its movement. A troubleshooting procedure must be capable of isolating a malfunctioning component in any of the component's failure modes.

d. Instrument (or Subject Instrument). The instrument which is the subject of the procurement to which this specification is appended.

e. Item. A generic term used to identify a hardware object. An item may be a part, subassembly, etc.

f. Job Guide. The step-by-step procedure for performing a task along with other task support data, formatted according to the requirements of section 3, comprise a Job Guide. Job Guides are prepared for all installation, operation, calibration, and preventive and corrective maintenance tasks.

g. Job Performance Aids (JPA). The term used to describe the complete set of Job Guides and Troubleshooting Aids for the instrument. The Job Performance Aids are assembled into activities and sections which make up the Instruction Manual.

h. Maintenance Significant Part (MSP). An item that is at the lowest level of hardware subordination found in troubleshooting by procuring agency technicians. A printed circuit board is an MSP because it is removed and replaced as a unit by agency technicians, i.e., no attempt is made to determine which of its individual components is malfunctioning.

i. Malfunction Symptom. A unique combination of one or more out-of-tolerance outputs. Note that (in some systems) for any given system state, the same symptom may appear as the result of any one of many different component failures, while some component failures may produce unique symptoms. Changing to a different system state may change the number and configuration of active components and may alter the symptom produced by any given component failure.

j. Output. Any individually identifiable path of energy or information flow away from the item under test (e.g., AC signal, supply voltage, flow rate).

k. Procurement (or Subject Procurement). That set of specifications and requirements describing an automatic air monitoring instrument, for the purpose of eliciting competitive bids from instrument vendors, to which this specification is appended.

l. Procuring Agency. That organizational entity which is immediately responsible for the use of the automatic air monitoring instrument obtained via the subject procurement. The procuring agency may be different from the organizational entity responsible for generating and negotiating the procurement, and for awarding the contract.

m. Step. A subdivision of information within a task. A step contains one to four sentences. Each sentence contains a verb that directs an action by the reader and an object toward which the action is directed.

n. System State. A unique data flow configuration of the item under test (for example, an instrument with the mode selector in the "ambient" position and the range selector in the "0.1" position). The checkout procedure for an item will be concerned only with system states that can be encountered as part of the start-up, operating, and shut-down sequence of the item (i.e., while the item is engaged in preparing for and executing its "mission"). Troubleshooting procedures will permit examination of all possible system states of an item, even those states that are not encountered in the normal operation of the item.

o. Task. A group of behaviors directed toward performing a piece of work upon a hardware item. A task to be included in the Instruction

Manual is identified in the TIM by "A/B" in a cell. The task name corresponding to a cell is formed by combining the verb (column heading) and the hardware name (row heading) that define the cell.

p. Troubleshooting Aids. Step-by-step procedures, with supporting information, developed to systematically and efficiently identify the existence of a malfunction and locate the malfunctioning part(s). Troubleshooting Aids include both Checkout Procedures and Action Trees.

q. Vendor (or Contractor). That organization contracted to produce and deliver the subject instrument and the Instruction Manual. Where the actual production of the Instruction Manual is subcontracted by the said contractor, then the term "vendor" as it appears in this specification shall apply to said subcontractor, except that the final responsibility for the delivery of the Instruction Manual produced in accordance with this specification shall rest with the prime contractor.

7.2 Performance Specification Definitions. The various performance specification definitions are defined as follows:

a. Fall time 90%. The interval between initial response time and time to 90% response after a step decrease in the inlet concentration.

b. Interference equivalent. The portion of indicated concentration due to the total of the interferences commonly found in ambient air.

c. Linearity. The maximum deviation between an actual instrument reading and the reading predicted by a straight line drawn between upper and lower calibration points.

d. Minimum detectable sensitivity. The smallest amount of input concentration which can be detected as concentration approaches zero.

e. Noise. Spontaneous deviations from a mean output not caused by input concentration changes.

f. Operating temperature fluctuation. The ambient temperature fluctuation over which stated specifications will be met.

g. Operation period. The period of time over which the instrument can be expected to operate unattended within specifications.

h. Precision. The degree of agreement between repeated measurements of the same concentration (which shall be the midpoint of the stated range) expressed as the average deviation of the single results from the mean.

i. Rise time 90%. The interval between initial response time and time to 90% response after a step increase in inlet concentration.

j. Span drift. The change in instrument output over a stated period of unadjusted continuous operation, when the input concentration is a stated upscale value.

k. Zero drift. The change in instrument output over a stated time period of unadjusted continuous operation, when the input concentration is zero.

7.3 Verb List. In the following list, each verb is defined in terms of one or more meanings associated with maintenance. A sample sentence has been provided for each usage. A number entry in the preference rank column indicates the standing of that verb compared to others with the same or similar meaning (highest rank is 1). Synonyms with which the verb was ranked are listed, in terms of their own raking. If a Synonym holds first rank, it is underlined. Where necessary, special notes are also included. Lower ranking verbs can be used when the first-ranked verb is particularly awkward or misleading in a given statement.

VERB LIST

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Accomplish	To do, carry out or bring about; to reach an objective.	Accomplish a periodic inspection on the sample filter.	2	1. Perform 2. Effect	
Actuate	To put into mechanical motion or action; to move to action.	Actuate the pump.	=		
Adapt	To make fit a new situation or use, often by modifying.	Use the bushing to adapt the new fuse to the existing fuseholder.	=		
Add	To put more in.	Add electrolyte to the cell.	=		
Adjust	1. To bring to a specified position or state.	1. Adjust the micrometer to the given measurements.	=		
	2. To bring to a more satisfactory state; to manipulate controls, levels, linkages, etc., to return equipment from an out=of=tolerance condition to an in=tolerance condition.	2. Adjust the regulator valve to obtain the required flow rate.			
Advise	To give information or notice to.	Advise man B that the power is on.	4	1. Report to 2. Inform 3. Notify 5. Communicate to	
Advance	To move forward; to move ahead	Advance the control	=		
Agitate	To move with a jerky, quick or violent action.	Agitate the container so that the solvent will be well mixed.	2	1. Shake	
Aid	To give help or support to; to assist.	Aid man B to lift the load.	3	1. Assist 2. Help	
Alert	To warn; to call to a state of readiness or watchfulness; to notify (a person) of an impending action.	Alert personnel that area will be cleared.	=		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Align	To bring into line, to line up; to bring into precise adjustment, correct relative position or coincidence.	Align pump and motor shafts.	=		
Allocate	To apportion for a specific purpose or to particular persons or things.	Allocate the various maintenance tasks to technicians.	3	1. Assign 2. Distribute	
Allow	1. To permit, to give opportunity to.	1. Allow the sediment to settle out.	1	2. Let	
	2. To allot or provide for.	2. Allow a 2-inch slack in the tubing.	1	2. Leave	
Alternate	To perform or cause to occur by turns or in succession.	Alternate between the two control settings.	=		
Apply	1. To lay or spread on.	1. Apply sealant liberally to both mating surfaces.	1	2. Put	Use "lubricate" rather than "apply lubricant."
	2. To energize.	2. Apply power or load.	=		
Arrange	To group according to quality, value or other characteristics, to put in proper order.	Arrange components by size from smallest to largest.	1	2. Order	
Ascertain	To find out with certainty that a proper condition exists.	Ascertain that the light is off.	5	1. Be sure 2. Verify 3. Check 4. Determine	
Assemble	To fit and secure together the several parts of; to make or form by combining parts.	Assemble the sampling train in accordance with specified procedures.	1	2. Construct	
Assess	To determine the importance, size or value of; to evaluate.	Assess the success of the maintenance action.	2	1. Evaluate	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Assign	To apportion to for a specific purpose or to particular persons or things; to appoint to a duty.	Assign the various maintenance tasks to technicians.	1	2. Distribute 3. Allocate	
Assist	To give support or help; to aid.	Assist man B to lift the instrument.	1	2. Help 3. Aid	
Assure	To make someone sure or certain, to inform positively.	Assure other technicians that all power is off.	=		
Attach	To join or fasten to.	Attach electrical leads to the VOM.	2	1. Connect	Use "tag" in preference to "attach" a tag.
Back off	To cause to go in reverse or backward.	Back off nut one full turn.	=		
Balance	To equalize in weight, height, number or proportion.	Balance the sample flow between the two outputs.	=		
Be sure	To confirm that a proper condition exists, to find out with certainty.	Be sure that the light is off.	1	2. Verify 3. Check 4. Determine 5. Ascertain	
Be careful	To exercise caution, to take care.	Be careful not to inhale the fumes of the solvent.	=		
Bend	To turn or force from straight or even to curved or angular, or to force, back to an original straight or even position.	Bend wire until it lies flat against the chassis.	=		
Bleed	To extract or let out some or all of a contained substance from.	Bleed off gas pressure.	=		
Blow	To send forth air, particularly from the lungs through the mouth.	Check for obstructions by disconnecting the hose at the air inlet and blowing through it.	=		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Break	1. To separate into parts with suddenness or violence.	1. Break the glass tubing at the score mark.	=		
	2. To pull away.	2. Break the pieces apart.	=		
Calculate	To determine by arithmetic processes.	Calculate the voltage in a circuit with 10 amp of current and 5 ohms of resistance.	1	2. Figure 3. Compute	
Calibrate	To determine accuracy, deviation or variation by special measurement or by comparison with a standard.	Calibrate the rotameter.	=		
Cap	To provide with a covering; to install or provide with a device for closing off the end of a tube which has a male fitting.	Cap all lines which have exposed male fittings.	1	2. Install caps	
Catch	To prevent from falling to the ground, to capture.	Catch any fluid drippings in a drip pan.	=		
Categorize	To put into categories or general classes.	Categorize components by their function.	2	1. Classify	For determining the classification of a supply item, use "identify"
Center	To place in the middle of.	Center the pointer on the dial.	=		
Change	To replace with another comparable item; to substitute serviceable equipment for malfunctioning, worn, or damaged equipment.	Change the switch contact points.	2	1. Replace	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Check	1. To confirm or establish that a proper condition exists; to ascertain that a given operation produces a specified result; to examine for satisfactory accuracy, safety or performance; to confirm or determine measurements by use of visual or mechanical means.	1. Check that the light is off.	3	1. Be sure 2. Verify 4. Determine 5. Ascertain	
	2. To perform a critical visual observation or check for specific conditions; to test the condition of.	2. Check the components for wear, deterioration or defects.	3	1. Inspect 2. Examine	
Checkout	To perform specified operations to verify operational readiness of a subcomponent, component, subsystem, or system.	Checkout the instrument.	1	2. Test	
Clamp	To fasten or press two or more parts together so as to hold them firmly.	Clamp the butt-to-butt connectors, using utility clamps.	-		
Classify	To put into categories or general classes.	Classify components by their function.	1	2. Categorize	For determining the classification of a supply item, use "identify"
Clean	To wash, scrub or apply solvents to; remove dirt, corrosion or grease.	Clean petroleum products from sample flowpath.	-		
Clear	To move people and/or objects away from.	Clear the area.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Close	1. To block against entry or passage; to turn, push or pull in the direction in which flow is impeded.	1. Close the valve.	-		
	2. To set a circuit breaker into the position allowing current to flow through.	2. Close the circuit breaker.	-		
Coat	To cover or spread with a finishing, protecting layer.	Coat "O" rings with silicone grease to prevent deterioration.	-		
Code	To put into the form or symbols of a system used to represent words; to mark with identifying symbols.	Color code equipment parts.	-		
Collect	To bring together into one body or place; to accumulate.	Collect the required hand tools.	-		
Communicate	1. To exchange information.	1. Communicate with man B during the entire procedure.	-		
	2. To make known.	2. Communicate to man B that the power is on.	5	1. Report to 2. Inform 3. Notify 4. Advise	
Compare	To examine the character or qualities of two or more items to discover resemblances or differences.	Compare the readings from the meter and strip chart.	-		
Compile	To compose or put together out of materials from several sources.	Compile the records of all maintenance on the instrument.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Comply	To conform with directions or rules; to accept as authority, to obey.	Comply with directions.	2	1. Follow	
Compress	To squeeze together; to condense.	Compress the spring fully.	-		
Compute	To determine by arithmetic processes.	Compute the voltage in a circuit with 10 amps of current and 5 ohms of resistance.	3	1. Calculate 2. Figure	
Condition	To put into a proper state for work or use.	Condition components before installing them.	-		
Confer	To consult; to exchange views.	Confer with maintenance supervisor if necessary.	-		
Connect	1. To bring or fit together so as to form a unit, to couple keyed or matched equipment items.	1. Connect the filter to the sample inlet fitting.	1	2. Mate 3. Join	
	2. To attach or mate (an electrical device) to a service outlet.	2. Connect the soldering iron to the service power outlet.	2	1. Plug in	
Consolidate	To join together into one whole, to form into a compact mass.	Consolidate contents of both containers.	-		
Construct	To make or form by combining parts; to fit and secure together the several parts of.	Construct the pump in accordance with specified procedures.	2	1. Assemble	
Control	To exercise restraining or directing influence over, to fix or adjust the time, amount or rate of.	Control sample flow rate.	2	1. Regulate	
Coordinate	To bring into a common action, movement or condition.	Coordinate the activities of man B and man C.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Copy	To make an imitation, transcript or reproduction of.	Copy the instrument number on the record form.	-		
Correct	To make or set right, to alter or adjust so as to bring to some standard or required condition.	Correct any error before proceeding with activity.	-		
Cover	To protect or shelter by placing something over or around.	Cover the photomultiplier tube to protect from light.	-		
Cut	To divide into parts using a sharp instrument such as a scissors or knife.	If the prongs of the cotter pin are too long, they should be cut to proper length.	-		
Deplete	To lessen markedly in quantity, content or power.	Deplete system pressure.	-		
Depress	To press or push down.	Depress the ON button.	-		
Depressurize	To release gas or fluid pressure from.	Depressurize the span gas system.	-		
Detect	To discover or determine the existence, presence or fact of.	Watch very carefully so as to detect any needle movement.	-		
Determine	1. To obtain definite and first-hand knowledge of, to confirm or establish that a proper condition exists.	1. Determine that the light is off.	4	1. Be sure 2. Verify 3. Check 5. Ascertain	
	2. To investigate and decide, to discover by study or experiment.	2. Determine the existence of span gas leaks.	1	2. Find	
Develop	To set forth or make clear by degrees or in detail.	Develop procedures fully.	-		
Disassemble	To take to pieces, to take apart to the level of the next smaller unit or down to all removable parts.	Disassemble sampling train.	1	2. Dismantle	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Dismantle	To take to pieces; to take apart to the level of the next smaller unit or down to all removable parts.	Dismantle the sampling train.	2	1. Disassemble	
Disconnect	1. To sever the connection between; to separate keyed or matched equipment parts.	1. Disconnect exhaust tubing from front of detector cell.	-		
	2. To detach or separate (an electrical device) from a service outlet.	2. Disconnect lamp cord from power supply.	2	1. Unplug	
Disengage	To release or detach interlocking parts, to unfasten; to set free from an inactive or fixed position.	Disengage the pump assembly.	2	1. Release 3. Unlock	For circuit breaker, use "open."
Dispatch	To send off or away with promptness or speed.	Dispatch report to supervising technician.	-		
Dispose of	To get rid of.	Dispose of unused absorbing reagent.	-		
Distribute	To apportion for a specific purpose or to particular persons or things.	Distribute the various maintenance tasks to technicians.	2	1. Assign 3. Allocate	
Drain	To draw off (liquid) gradually or completely.	Drain excess water from glassware.	-		
Draw in	To pull (liquid) up into a container through suction.	Draw in 10 ml of absorbing reagent.	1	1. Pipette	
Dry	To cause to be free from water or liquid.	Dry the spectrophotometer cells with lint-free cloth.	-		
Effect	To do, carry out or bring about; to reach an objective.	Effect a periodic inspection of the recorder.	3	1. Perform 2. Accomplish	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Eliminate	To expel; to ignore or set aside as unimportant.	Eliminate all unnecessary movement.	-		
Employ	To put into action or service, to carry out a purpose or action by means of; to avail oneself of.	Employ only stainless steel tubing.	3	1. Use 2. Utilize	
Enforce	To compel or constrain.	Enforce safety regulations.	-		
Engage	To cause to interlock or mesh.	Engage threads of female fitting to threads of the male fitting.	-		For circuit breakers, use "close."
Enter	To put on record.	Enter the data on the form.	2	1. Record	
Erect	To put up by fitting together.	Erect a special maintenance stand.	-		
Establish	To set on a firm basis.	Establish safety rules.	-		
Estimate	To judge or determine roughly the size, extent or nature of.	Estimate amount of absorbing reagent which will be necessary.	-		
Evaluate	To determine the importance, size or nature of; to appraise; to give a value or appraisal to on the basis of collected data.	Evaluate an operating monitor.	1	2. Assess	
Examine	To perform a critical visual observation or check for specific conditions; to test the condition of.	Examine the component for wear, deterioration or defects.	2	1. Inspect 3. Check	
Expedite	To accelerate the process or progress of.	Expedite the activity by assigning two men.	-		
Extend	To cause to be drawn out to fullest length.	Extend the tubing.	-		
Extract	To draw forth; to pull out forcibly.	Extract the cotter pin.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Fabricate	To construct from standardized parts.	Fabricate a plug to seal the sample inlet.	-		
Figure	To determine by arithmetic processes.	Figure the voltage in a circuit with 10 amps of current and 5 ohms of resistance.	2	1. Calculate 3. Compute	
File	To rub smooth or cut away with a file (i.e., a tool with cutting ridges for forming or smoothing surfaces.)	File one end of the rod to a point.	-		
Fill	To put into as much as can be held or conveniently contained.	Fill a 1 cm spectrophotometer cell.	-		
Find	1. To discover or determine by search; to indicate the place, site or limits of.	1. Find the needle valve.	2	1. Locate	
	2. To discover by study or experiment; to investigage and decide.	2. Find the ozone concentration corresponding to the sum, using the conversion table.	2	1. Determine	
Flush	To pour liquid over or through; to wash out with a rush of liquid.	Flush the cell with distilled water.	-		
Follow	To accept as authority, to obey; to conform with directions or rules.	Follow directions.	1	2. Comply with	
Form	To give a particular shape to; to shape or mold into a certain state; to make up.	Form the tubing so that no bend radius is less than 3 inches.	-		
Furnish	To supply what is needed, to equip.	Furnish a flashlight for man B.	2	1. Provide	
Go to	To proceed to.	Go to Step 14.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Ground	To connect a current, wire or a piece of electrical equipment to a land or other specified surface.	Ground the monitor.	-		
Guard	To protect from danger, to defend.	Guard the absorbing reagent against contamination.	-		
Guide	To manage or direct the movement of.	Guide the instrument stand safely to its new position.	-		
Hand	To give, pass or transmit with the hands.	Hand the sample probe through the hole to technician B.	-		
Handle	To manipulate (load, turn, raise, etc.) objects and equipment manually or with specially designated equipment, such as hoists.	Handle ethylene cylinders carefully.	-		
Hang	To fasten to some elevated point without support from below, to suspend.	Do not hang tools on projecting parts of the monitor.	-		
Help	To give support, aid or assistance to.	Help man B lift the air cylinder.	2	1. Assist 3. Aid	
Hold	To have or keep in the grasp.	Hold the power switch in position until the voltmeter stabilizes.	-		
Identify	1. To establish the identity of.	1. Identify components by name and function.	-		
	2. To determine the classification of a supply item.	2. Identify the component to be ordered from manufacturer.	-		
Indicate	To point out.	Indicate which dial should be monitored.	-		
Inform	To make known to; to give notice or report the occurrence of.	Inform man B that the power is on.	2	1. Report to 2. Notify 4. Advise	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Initiate	To perform actions necessary to set into operation, to set going, to begin.	Initiate operation of the monitor.	1	2. Start	
Inject	To throw, drive or force in.	Inject lubricant into pump bearing.	-		
Insert	To put or thrust in, into or through.	Insert a wire through the hole in the fastener.	1	2. Put	
Inspect	To perform a critical visual observation or check for specific conditions; to test the condition of.	Inspect the components for wear, deterioration or defects.	1	2. Examine 3. Check	
Install	1. To perform operations necessary to properly fit an equipment unit into the next larger assembly or system.	1. Install new pump on mounting plate.	-		a. For wiring a circuit, use either "install wiring" or "wire." b. For safety wiring use either "safety wire" or "install safety wire." c. For screws, use "install screws" rather than "screw." d. Use "cap" "plug" rather than install caps (plugs)
	2. To place and attach.	2. Install two screws	-		
Insure	To make certain, to ensure.	Insure that scribe marks on valve assembly and pump casting are aligned.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Interpret	To explain the meaning of.	Interpret instructions for inexperienced technicians.	-		
Isolate	To use test equipment to identify or select a source of trouble.	Isolate the source of a malfunction using troubleshooting checkout.	-		
Join	To bring or fit together so as to form a unit; to couple keyed or matched equipment items.	Join the butt-to-butt connections using utility clamps.	3	1. Connect 2. Mate	
Keep	To remain, to continue in a place.	Keep fingers away from fan blades.	2	1. Stay	
Latch	To catch with a device which holds a door when closed, even if not bolted.	Close and latch top cover.	-		
Leave	1. To go away from, depart.	1. Do not leave the area until this activity is complete.	-		
	2. To allot or provide for.	2. Leave a two-inch slack in the stainless steel tubing.	2	1. Allow	
Let	To permit; to give opportunity to.	Let the ozone monitor stabilize.	2	1. Allow	
Level	To cause all objects to become even or parallel with the horizon.	Level the monitor in accordance with specified procedure.	-		
Lift	To move or cause to be moved from a lower to a higher position; to elevate.	Lift the ethylene cylinder into position.	2	1. Raise	
Light	To cause to illuminate	Light the overhead light.	-		
Listen	To pay attention to sound.	Listen to the pump while it is operating.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Load	To place in or on a means of conveyance.	Load the monitor onto the cart.	-		
Locate	1. To find, determine or indicate the place, site or limits of.	1. Locate the leak detector solution.	1	2. Find	
	2. To set or establish in a particular spot, to station.	2. Locate the test equipment so that it can be seen by both technicians.	3-4	1. Position 2. Place 3-4. Set 5. Put	
Lock	To hold fast or inactive, to fix.	Lock "ZERO ADJUST" control.	-		
Look for	to visually search for.	Look for cracks, corrosion and damage during inspection of tubing.	-		
Loop	To make into the form or shape of a loop.	Loop the tubing loosely behind the monitor.	-		
Loosen	To release from restraint, to cause to become less tight fitting.	Loosen wing nuts and remove frame.	-		
Lower	To cause to move down; to depress as to direction.	Lower the valve assembly into the pump body.	-		
Lubricate	To put libricant on specified locations.	Lubricate the motor bearings.	1	2. Apply lubricant	
Maintain	1. To hold or keep in any particular state or condition, especially in a state of efficiency or validity.	1. Maintain the monitor in a ready-to-operate condition.	-		
	2. To sustain or keep up.	2. Maintain daily records of ozone concentration.	-		
Make	To carry out or cause to occur.	Make corrections, where necessary.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Mark	To label, to provide with an identifying or indicating symbol.	Mark both parts to help in reassembly.	-	1. Tag	If marking is to be done on a tag, use "tag"
Mate	To join or fit together, to couple.	Mate the two parts of the connector.	2	1. Connect 3. Join	
Measure	To determine the dimensions, capacity or amount by use of standard instruments or utensils.	Measure the absorbance of each cell using spectrophotometer.	-		
Mix	To combine or blend into one mass.	Mix the two reagents.	-		
Modify	To alter or change somewhat the form or qualities of.	Modify the flow rate as necessary.	-		
Monitor	1. To visually take note of, to pay attention to in order to check on action or change.	1. Monitor the meter for changes in ozone concentration.	3	1. Observe 2. Watch	
	2. To continually or periodically attend to displays to determine equipment condition or operating status.	2. Monitor the meter during start-up.	-		
Mount	To attach to a support.	Mount flow meter in vertical position.	-		
Move	To change the location or position of.	Move and position the monitor.	-		
Neutralize	To destroy the effectiveness of, to nullify, to make chemically neutral or electrically inert.	Neutralize the reagent before using.	-		
Notify	To make known to; to give notice or report the occurrence of.	Notify man B that the power is on.	3	1. Report to 2. Inform 4. Advise 5. Communicate to	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Observe	1. To conform one's actions or practice to.	1. Observe precautions.	-		
	2. To visually take note of, to pay attention to.	2. Observe the cylinder gauge for changes in pressure.	1	2. Watch 3. Monitor	
Obtain	1. To get or find out by observation or special procedures.	1. Obtain a reading on the VOM.	2	1. Take	
	2. To gain or attain.	2. Obtain the necessary supplies before starting on maintenance.	-		
Open	1. To move from closed position; to make available for passage by turning in an appropriate direction.	1. Open the valve.	-		
	2. To disengage or pull.	2. Open the appropriate circuit breakers.	-		
Operate	To control equipment in order to accomplish a specific purpose.	Operate monitor as prescribed in checkout.	-		
Order	1. To requisition or request from supply.	1. Order 65 ml of absorbing reagent.	-		
	2. To group according to quality, value, or other characteristics.	2. Order components by size from smallest to largest.	2	1. Arrange	
Organize	To arrange elements into a whole of interdependent parts; to form into a coherent unity; to integrate.	Organize the activities of the assisting technicians.	-		
Orient	1. To acquaint with the existing situation or environment.	1. Orient new technicians to location of equipment and supplies.	-		
	2. To set or arrange in any determinate position.	2. Orient the monitor so that the meter is easily visible.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Overhaul	The act of disassembling equipment units down to all removable parts; cleaning; critically inspecting, repairing, restoring and replacing where necessary; assembling, adjusting, aligning, recalibrating and verifying operational readiness by test or checkout; and packaging for transportation storage.	Overhaul the pump.	-		
Pack	To fill completely with grease.	Pack the bearings.	-		
Paint	To apply color or pigment (suspended in suitable liquid) to the surface of.	Paint all exposed surfaces.	-		
Perform	To do, carry out or bring about; to reach an objective.	Perform a periodic inspection of the cylinder for leakage.	1	2. Accomplish 3. Effect	
Pipette	Use of small pipette apparatus equipped with suction to withdraw a measured amount of fluid.	Pipette 10 ml of absorbing reagent into each absorber.	2	1. Draw in	
Place	To put or set in a desired location or position	Place the test equipment so that it can be seen by both technicians.	2	1. Position 3-4. Set 3-4. Locate 5. Put	
Plug	To provide with a device for closing off the end of a tube which has a female fitting.	Plug all lines which have exposed female fittings.	1	2. Insert plugs 3. Install plugs	
Plug in	To attach or mate (an electrical device) to a service outlet.	Plug in the soldering iron at the power outlet.	1	2. Connect	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Position	To put or set in given place, to locate.	Position the test equipment so that it can be seen by both technicians.	1	2. Place 3-4. Set 3-4. Locate 5. Put	
Post	To station at a given place.	Post one man in front of the monitor.	-		
Prepare	To prepare or make ready for a maintenance activity.	Prepare the supplies and tools needed for a checkout.	1	2. Set up 3. Ready	
Pre-set	To put in a desired position, adjustment or condition beforehand.	Pre-set the VOM at its highest scale.	-		
Press	To act upon through thrusting force exerted in contact.	Press diverter valve when bubble reaches 0 on bubblemeter scale.	1	2. Depress 3. Push	For circuit breakers, use "close."
Prevent	To keep from happening or existing.	Prevent reagent from spilling onto electrical contacts.	-		
Probe	To investigage thoroughly with a long, pointed device or by direct feeling.	Probe the tubing with fingers.	-		
Provide	To supply what is needed, to equip.	Provide a flashlight for man B.	1	2. Furnish	
Pull	To exert force upon an object so as to cause motion toward the force.	Pull diverter valve outward.	-		For circuit breakers, use "open."
Pump	Raise or lower by operating a device which raises, transfers or compresses fluids by suction, pressure or both.	Pump 10 ml of absorbing reagent into each absorber.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Puncture	To pierce with pointed instrument or object.	Be careful not to puncture tubing while probing the inside.	-		
Purge	To free of sediment or trapped air by flushing or bleeding.	Purge the span gas system.	-		
Push	To press against with force so as to cause motion away from the force.	Push diverter valve.	2	1. Press	For circuit breakers, use "close."
Put	1. To place or set in a desired position or location.	1. Put the test equipment where it can be seen by both technicians.	5	1. Position 2. Place 3-4. Set 3-4. Locate	
	2. To deposit or leave.	2. Put necessary tools on work surface	-		Use "store" instead of "put away" for depositing or leaving in a specified place for future use.
	3. To lay or spread on or in.	3. Put sealant liberally on both mating surfaces.	1	1. Apply	
Raise	To move or cause to be moved from a lower to a higher position, to elevate.	Raise the access cover.	1	2. Lift	
Read	To interpret the meaning of by visual observation.	Read the VOM.	-		
Readjust	To adjust again, to move back to a specified condition; to bring back to an in-tolerance condition.	Readjust the voltage after performing an operational check of the system.	-		
Ready	To prepare for a maintenance activity.	Ready supplies and tools needed for a checkout.	3	1. Set up 2. Prepare	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Reassemble	To refit and secure together the parts after they have been taken apart.	Reassemble fitter assembly.	-		
Receive	To come into possession of; to get.	Receive supplies as they arrive.	-		
Recommend	To urge the acceptance or use of.	Recommend procedural changes where appropriate.	-		
Recondition	To renew; to bring or put back into good condition.	Recondition the pumps.	1		
Reconnect	To rejoin or refasten that which has been separated.	Reconnect stainless steel tubing to ethylene regulator.	-		
Record	To set down in writing.	Record ozone readings on appropriate forms.	1	2. Enter	
Reduce	To cause to be diminished in strength, density or value.	Reduce pump flow rate.	-		
Regulate	To fix or adjust the time, amount or rate of; to exercise restraining or directing influence over.	Regulate the sample flow rate as necessary.	1	2. Control	
Reject	To refuse to have, use or take for some purpose.	Reject components which show excessive wear.	-		
Relay	To pass along by stages.	Relay the message to man B.	-		
Release	1. To set free from an inactive or fixed position; to unfasten or detach interlocking parts.	1. Release the spring tension.	1	2. Disengage 3. Unlock	
	2. To let go of.	2. Release the handle of the spring-loaded switch.	-		
	3. To set free from restraint or confinement.	3. Release pressure.	-		
Relieve	To ease or set free of a burden, to partially release.	Relieve pressure before working on the equipment.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Remove	1. To perform operations necessary to take an equipment unit out of the next larger assembly or system.	1. a. Remove ozone generator. b. Remove four screws.	-		For screws, use "remove" rather than "unscrew."
	2. To take off or eliminate.	2. Remove paint.	-		
Repair	To restore damaged, wornout or malfunctioning equipment to a serviceable, usable or operable condition.	Repair monitor by replacing parts and removing defects.	1		Repair includes replacement, overhaul and reworking of constitutent parts or materials.
Repeat	To make, do or perform again.	If leaks are detected, repeat checkout of tubing connections.	-		
Replace	1. To restore to a former place or position.	1. Replace screws.	1		
	2. To substitute serviceable equipment for malfunctioning, wornout or damaged equipment.	2. Replace the switch contact points.	1	2. Change	
Replenish	To fill or build up again.	Replenish maintenance supplies as often as necessary.	-		
Report	To describe as being in a specified state.	Report when ready	1	2. Inform 3. Notify 4. Advise 5. Communicate to	
	To make known to; to give notice or report the occurrence of.	Report to man B that the power is on.			
Request	To ask for.	Request further information if necessary.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Reset	To put back into a desired position, adjustment or condition.	Reset power switch to ON.	-		
Resolve	To clear up or find an answer to; to reach a decision about.	Resolve the inconsistency before proceeding with maintenance activity.	-		
Return	To bring, send or put back to a former or proper place.	Return the monitor to a stable state before calibrating.	-		
Review	To examine again; to go over or examine critically or deliberately.	Review procedures which have not been performed for more than two months.	-		
Rinse	To cleanse (as from soap used in washing) by clear water.	Rinse the absorbers in distilled water and shake out excess.	-		
Rotate	To cause to revolve about an axis or center.	Rotate the ethylene cylinder valve fully clockwise.	1	2. Turn	
Rub	To move along the surface of a body with pressure.	Rub and over mating surfaces and assure that they are smooth.	-		
Safeguard	To provide a technical contrivance to prevent accident; to comply with precautionary measures or stipulation.	Safeguard personnel by using caution in handling ethylene gas.	-		
Scan	To make a wide, sweeping search of; to look through or over hastily.	Scan the monitor's controls before checkout begins.	-		
Schedule	To appoint, assign or designate for a fixed future time; to make a time-table of.	Schedule maintenance activities to minimize down time.	-		
Scrub	To clean with hard rubbing.	Scrub glassware to remove all deposits.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Select	To take by preference or fitness from a number or group, to pick out, to choose.	Select the appropriate VDC range on the VOM.	-		
Service	To perform such operations as cleanup, lubrication and replenishment to prepare for use.	Service the sample filter as required.	-		
Set	1. To put a switch, pointer or knob into a given position; to put equipment into a given adjustment, condition a mode.	1. Set power switch to ON.	-		
	2. To put or place in a desired orientation or location.	2. Set the test equipment so that it can be seen by both technicians.	3-4	1. Position 2. Place 3-4. Locate 5. Put	
Set up	To prepare or make ready for a maintenance activity.	Set up the monitor for checkout.	2	1. Prepare 3. Ready	
Shake	To move or cause to move to and fro in a quick, jerky manner.	Shake the glassware to remove excess water.	-		
Shut down	To perform operations necessary to cause an equipment to cease or suspend operation.	Shut down spectrophotometer according to manufacturer's instructions.	1	2. Stop	
Signal	To notify or communicate by signals (i.e., a prearranged sign, notice or symbol conveying a command, warning, direction or other message).	Signal man B that power is ON.	-		
Slide	To cause to move in a smooth manner over a surface.	Slide lamp out of generator.	-		
Specify	To name or state explicitly or in detail.	Specify the manufacturer's number of the multimeter.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Spill	To cause or allow to fall, flow or run out.	Do not spill reagent on clothing, hands.	-		
Spin	To cause to revolve rapidly.	Spin motor shaft by hand to be sure that it does not bind.	-		
Start	To perform actions necessary to set into operation, to set going, to begin.	Start the monitor.	2	1. Initiate	
Stay	To remain, to continue in a place.	Stay away from the danger area.	1	2. Keep	
Stimulate	To excite to activity or greater activity.	Stimulate flow by warming the lines.	-		
Stop	To perform actions necessary to cause an equipment to cease or suspend operation.	Stop the flow.	2	1. Shut down	
Store	To deposit or leave in a specified place for future use.	Store required tools in the appropriate maintenance area.	1	3. Put away	
Strike	To deliver or aim a blow or thrust, to hit.	Strike the designated spot with a hammer.	-		
Submit	To make available, to offer.	Submit request for primary calibration.	-		
Suggest	To propose as desirable or fitting; to offer for consideration.	Suggest any changes which might be helpful.	-		
Support	To hold up or provide a foundation or props for.	Support the tubing at both ends.	-		
Survey	To examine comprehensively as to condition, situation or value.	Survey entire sampling train to assure that all connections have been made.	-		
Synchrcnize	To cause to happen at the same time.	Synchronize the activities of man A and man B.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Tabulate	To set up in the form of a table (with rows and columns); to compute by means of a table.	Tabulate maintenance times for each occurrence of the various maintenance activities.	-		
Tag	To provide with an identifying or indicating symbol with or as if with a tag (i.e., a cardboard, plastic or metal marker used for identification or classification); to label.	Tag and disconnect wiring pump assembly.	1	2. Attach a tag 3. Mark 4. Connect a tag to	
Take	1. To get into or carry in one's hands or one's possession.	1. Take supplies to the maintenance area.	-		
	2. To get or find out by observation or special procedures.	2. Take a reading on the VOM.	1	2. Obtain	
Tap	To strike lightly.	Tap the eye of the cotter pin to seat it.	-		
Test	To perform specified operations to verify operational readiness of a component, subcomponent, system or subsystem.	Test the sample flow-path for leaks.	2	1. Checkout	
Tighten	1. To perform necessary operations to fix more firmly in place.	1. Tighten all screws.	-		
	2. To apply a specified amount of force to produce a rotation or twisting motion to fix more firmly in place.	2. Tighten teflon fitting only finger-tight.	2	1. Torque	
Tilt	To cause to slope, lean or incline.	Tilt instrument to expose adjustable mounts.	-		

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Torque	To apply a specified amount of force to produce a rotation or twisting motion to fix more firmly in place.	Torque metal fittings only finger-tight plus 3/4 turn with a wrench.	1	2. Tighten	Torque (noun) = length of wrench handle times applied force.
Trace	To follow or study out in detail or step by step.	Visually trace the wiring diagram.	-		
Transfer	To convey or cause to pass from one place to another.	Transfer absorbing reagent from absorber into a clean spectrophotometer cell.	1		
Transport	To carry by hand or in a vehicle or hoist, or in a container, etc.	Transport instrument in its shipping container.	-		
Troubleshoot	To localize, isolate and correct the source of a malfunction or breakdown.	Troubleshoot the monitor using the appropriate checkout procedures.	-		
Turn	To cause to revolve about an axis or center.	Turn valve on air cylinder fully counterclockwise.	2	1. Rotate	
Turn off	To shut off or stop the flow of by or as if by moving a control to its OFF position.	Turn off power to the monitor.	-		
Turn on	To cause to flow or operate by or as if by moving a control to its ON position.	Turn on power to the monitor.	-		
Uncap	To remove a device (i.e., a cap) for closing off the end of a tube with a male fitting.	Uncap the sample inlet fitting line.	2	1. Remove caps	
Unlock	To set free from an inactive or fixed position, to unfasten, to detach interlocking parts.	Unlock the ZERO ADJUST control.	3	1. Release 2. Disengage	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Unplug	1. To detach or separate (an electrical device) from a service outlet.	1. Unplug the soldering iron.	1	2. Disconnect	
	2. To remove a device (i.e., a plug) for closing off the end of a tube with female fittings.	2. Unplug the vacuum line.	2	1. Remove plugs	
Unscrew	To draw the screws from.	Unscrew twelve screws around cover.	2	1. Remove	
Use	To put into action or service, to avail oneself of; to carry out a purpose or action by means of.	Use only stainless steel tubing in the sample introduction and calibration sample systems.	1	2. Utilize 3. Employ	
Utilize	To put into action or service; to avail oneself of; to carry out a purpose or action by means of.	Utilize only stainless steel tubing in the sample introduction and calibration sample systems.	2	1. Use 3. Employ	
Verify	1. To confirm or establish that a proper condition exists.	1. Verify that the light is off.	2	1. Be sure 3. Check 4. Determine 5. Ascertain	
	2. To establish the truth or accuracy of.	2. Verify the readings before recording them.	-		
Wait	To suspend activity in a sequence of activities until a given condition occurs or a given time has elapsed.	Wait 10 minutes before proceeding.	-		
Wash	To cleanse by or as if by the action of liquid; to remove (dirt) by rubbing or drenching with liquid.	Wash the glassware with a cleaning solution and a stiff brush.	-		
Watch	To visually take note of, to pay attention to in order to check on action or change.	Watch sample-plus ethylene flow meter for changes.	2	1. Observe	

VERBS	DEFINITIONS	EXAMPLES	PREF. RANK	SYNONYMS BY ORDER OF PREFERENCE	NOTES
Withdraw	To take back, away, or out.	Withdraw vane assembly from the pump.	-		
Wrap	To wind, coil or twine so as to encircle or cover something.	Wrap the wire around the terminal.	-		
Zero	To bring to a desired level or null position.	Zero the meter with power OFF.	-		

APPENDIX A

Guidelines for In-Process Review of Instruction Manual

Guidelines for In-Process Review of Instruction Manual

The specification provides the purchaser (i.e., the procuring agency) with two Options for reviewing the interim products from which the Instruction Manual is derived:

1. Option 1. Pre-existing Instruction Manual Available. In this case, the vendor supplies the manual and interim products (developed, following the specification, for a previous procurement) as part of his bid/proposal.
2. Option 2. No Pre-existing Instruction Manual Available. Where no JPA-type manual exists, the vendor develops it according to the specification and submits interim products as they are developed.

In both cases, the vendor supplies the data base documents, schematics, diagrams, etc., from which the product is developed. Each of the products, including the draft version of the manual itself, should be evaluated using the criteria outlined below. Where the purchaser cannot review each product completely, he should at least spot check each one. The most important single interim product is the Task Identification Matrix, and the purchaser should place emphasis on its review.

Task Identification Matrix (TIM)

The vendor should be able to provide a TIM which meets the following criteria:

1. The format of the TIM and the makeup of hardware and maintenance codes are in accordance with the specification.
2. The TIM is complete. Each matrix cell must contain an appropriate entry and all hardware items from the hardware data base must be listed. The data base may be established by a provisioning list or other document invoked by the contract Statement of Work, that reflects the total hardware data base, such as an Illustrated Parts Breakdown or a Repair Parts and Special Tools List.

3. The TIM is accurate. A careful comparison of hardware breakdown level in the TIM with its original data base document must show that they are identical.
4. Additional maintenance functions, if employed, are consistent with the verb list (7.3) and are appropriate.
5. Adequate rationales exist for all decisions concerning whether tasks are to be performed by agency or by vendor technicians.
6. Adequate rationales exist for all Head/Book Tradeoff decisions.

Test Equipment and Tool Use Form (TETUF)

The Test Equipment and Tool Use Form should satisfy the following requirements:

1. The format and content of the TETUF are in accordance with the specification.
2. The test equipment and tools listed in the TETUF are those which are typically available to the procuring agency technician.
3. The test equipment functions and standard statements which are included accurately reflect the user's expected capabilities as defined in 1.5.

Detailed Step Description Worksheet

These worksheets, prepared for each task, should satisfy the following requirements:

1. The entires are complete and accurate.
2. The entries agree with the source documentation from which they were derived.

Job Guides

Job Guides should satisfy the following requirements:

1. All Job Guides comply with the writing requirements of the specification concerning standardization of style (particularly for terminology), nomenclature, completeness and syntax of steps, and the compatibility of text-to-illustration in each frame.
2. All Job Guide content accurately reflects the information developed in the task analysis stages.
3. All Job Guide illustrations are clear, understandable, and appropriate to the text. They comply with the specification in terms of standardized line weights, exploded view detail, callout sequence, illustration sizing, and typography.
4. The formatting of all Job Guide text and illustrations on each frame is planned so that maximum use is made of available image area without compromising illustration legibility.

Function/Function Failure Analysis

Each list of Function/Function Failures should satisfy the following requirements:

1. The list contains all "Found in Troubleshooting" components for the related Checkout/Troubleshoot task.
2. The failure modes for each component are appropriate to the type of component.
3. The list is prepared in accordance with the specification.

Lists of Malfunction Symptoms

Each list of Malfunction Symptoms must demonstrate that:

1. Every unique symptom that can be displayed by the unit under test is listed.

2. All of the system states that occur during the normal start-up and operating sequence have been considered.

Checkout Procedures

The criteria for the Checkout Procedures are as follows:

1. Each Checkout Procedure encompasses each and every malfunction symptom on the List of Malfunction Symptoms for the task.
2. There is a Checkout Procedure for every Checkout/ Troubleshoot task entry in the TIM.

Action Trees

The review must assure the procuring agency reviewer that all specification guidelines are being followed in the preparation of Action Trees so that when presented at validation they will exhibit the highest degree of accuracy, completeness, and logical presentation. The Action Trees should satisfy the following requirements:

1. They utilize only procuring agency authorized test equipment and tools.
2. Their testing locations were selected in a logical manner consistent with the specification guidelines and the functional organization of the equipment.
3. Half-splitting decisions used in the preparation of Action Trees take into account the practical considerations listed in 4.5.3.2.
4. There is a separate Action Tree for every malfunction symptom identified in the Checkout Procedure.
5. The Action Trees for a procedure isolate all component failure modes in the Function/Function Failure List for that procedure.

Pre-Publication Draft

In Option 1, the vendor will supply a pre-publication draft. Assuming that technical evaluation has already been performed on Job Guides, Checkout Procedures, and Action Trees, the major function of this evaluation will be to assure that:

1. Errors have not been introduced in the final layout of the manual.
2. The layout is logical, not confusing, and easy to employ.
3. Is consistent with the specification.

The procuring agency may wish to arrange with the vendor to perform Verification (see Appendix B) using the pre-publication draft, to avoid producing final copies which could contain errors.

Scheduling

The specification purposely avoids delimiting time periods within which review must occur, because this may vary widely with the unique constraints upon the individual purchaser. Bidders with potentially acceptable manuals will present them as part of their bid/proposal package (see 6.11), and the (Option 1) review can be performed as desired during the bid evaluation period. Where a bidder is selected who does not have an acceptable manual (an Option 2 situation), a schedule for review of products should be arranged during contract negotiation. The schedule should have the following characteristics:

1. It should specify deadlines, between contract initiation and instrument delivery, for submission of all interim products and the pre-publication draft. Unless it is critical that the instrument be installed as soon as possible, it is generally not wise to accept delivery of the instrument before delivery of the pre-publication draft. The vendor may discover problems in the instrument during validation of the manual and it is less troublesome for both the vendor and purchaser to correct such problems before delivery.

2. The schedule need not state the level of review (e.g. complete review, 75%, 10% random spot check) that will be given a particular product.

3. The amount of time the purchaser allows himself for review of each product should be such that the vendor's validation of the products, which must follow review, can be properly accomplished. The assumption is that the vendor will always know the instrument better than the purchaser and so is better able to discover errors in technical detail which escaped the procuring agency reviewer. Thus, it is important that enough time be allowed for validation to be properly performed.

APPENDIX B

Guidelines for Verification
of the
Instruction Manual

Guidelines for Verification of the Instruction Manual

Verification should be performed by the procuring agency to guarantee the adequacy, accuracy, and completeness of the JPA Validation process and the manual as developed by the vendor. As a result of Validation and Verification, the JPA Instruction Manual will be known to be acceptable as a reliable, effective user document.

The procuring agency should employ personnel for the verification process that most nearly meet the training and talent background of the intended user technician. The technician will perform each procedure with no assistance other than the aid of the JPA manual. When problems arise in his performance, they are recorded by procuring agency and vendor representatives. Although verification is an agency function, the vendor may find it in his interest to be represented by technical/publications personnel who are capable of correcting procedures found to be in error or inappropriate to the skill level of the subject technician. The specification requires the vendor to immediately correct deficiencies detected during verification.

The JPA approach requires that verification be accomplished by introducing malfunctions which the user technician attempts to discover and isolate using the instruction manual. Though it is contrary to common practice to verify conventional troubleshooting data through insertion of malfunctions in the hardware, it is particularly important that it be done in the case of JPA-type Troubleshooting Aids. The user will be wholly dependent on the data when troubleshooting in the fully proceduralized mode, thus it will be impossible for him to tell that he has made an error until he completes a directed repair procedure and discovers that the malfunction still exists. In such a case he has two choices--call another technician who can troubleshoot by other means, or repeat the procedure himself on the assumption that he made an error the first time. If the error is in the data, he will fail again to solve the problem. Thus it is critical that errors in troubleshooting be uncovered--if not in Validation, then in Verification.

The Verification process involves four steps:

1. Introduction, over several trials, of malfunctions which thoroughly test the manual.
2. For each such trial, performance of the appropriate Checkouts, Action Trees, and Job Guides by a user technician-representative person, who discovers, isolates, and corrects the malfunction. Additional trials may involve simply the performance of tasks (e.g. installation and preventative maintenance) which are not referred from the Action Trees.
3. Evaluation of the Trials to determine whether difficulties observed were the result of problems in the manual.
4. Reporting problems in the manual to the vendor, so that corrections can be made.

It is recommended that, as a minimum, every checkout procedure, and at least one Action Tree following each checkout should be verified. Longer Action Trees should be preferred over shorter ones since more test points are verified. Where resources permit more than one Action Tree to be exercised per checkout, choose action trees with a minimum of overlapping test points.

Should the verifier fail to identify a malfunction which has been inserted into the hardware, it must first be determined whether the verifier exactly followed the procedure as specified. It he did not, it must be determined whether he simply erred or whether there is some characteristic of the data which contributed to his error--a word he did not understand, an ambiguous phrase, etc. If he followed the procedure exactly it must be determined that all special tools and test equipment are operating properly and that the instrument contains no malfunctions save the one under test. If no problem of this sort can be found there must be an error in the data. The fault may be in an incorrect reading or tolerance, switch setting, reference, or an omission. The cause of the error must be found before it can be determined what details of the manual must be changed to assure successful identification of the malfunction.

All errors discovered in the Verification are compiled and forwarded to the vendor as the final activity in the verification process. In cases where the error (e.g. in an Action Tree) cannot specifically be identified, the vendor should be provided with all available information concerning the problem.